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Press Illustrating Service

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Gravitation—I*

And the Pr' ciple of Relativity

By A. S Eddington, F.R.S.

THERE were many difficulties to encounter in entering the room just now. To begin with, we had to bear the crushing load of the atmosphere, amounting to 14 lb. on every square inch. At each step forwards it was necessary to tread gingerly on a piece of ground moving at the rate of twenty miles a second on its way round the sun. We were poised precariously on a globe, apparently hanging by our feet, head outwards into space. And this acrobatic feat was performed in the face of a tremendous wind of æther, blowing at I do not know how many miles a second literally through us. We do not claim much credit for overcoming these difficulties—because we never noticed them. But I venture to remind you of them, because I am about to speak of some other extraordinary things that may be happening to us of which we are quite unconscious.

Not to go too far back in history, the present subject arises from a famous experiment performed in the year 1887, known as the Michelson-Morley experiment. The apparatus was elaborate, but the principle of the experiment is not very difficult. If you are in a river, which will be the quicker—to swim to a point fifty yards up stream and back again, or to a point fifty yards across stream and back again? Mathematically the answer is, perhaps, not immediately obvious, because the net effect of the current is a delay in both cases. But I think that anyone whom has swum in a river will have no hesitation about the answer. The up-and-down journey takes longer. Now we *are* in a river—of æther. There is a swift current of æther flowing through this room; or, if we happen to be at rest in the æther at the present moment, six months hence the earth's orbital motion will be reversed, and then there must be a swift current. Michelson divided a beam of light into two parts; he sent one-half swimming up the stream of æther for a certain distance, and then by a mirror back to the starting point; he sent the other half an equal distance (as he thought) across the stream and back. It was a race; and with his apparatus he could test very accurately which part got back first. To his surprise, it was a dead-heat. Clearly the two paths could not really have been equal, the along-stream path must have been a little shorter to compensate for the greater hindrance of the current. That objection was foreseen, and the apparatus, which was mounted on a stone pier floating in mercury, was rotated through a right angle, so that the arm which was formerly along the stream was now across the stream, and *vice versa*. Again the two portions of the beam arrived at the same moment; so this time the other arm had become the shorter—simply by altering its position. In fact, these supposedly rigid arms had contracted when placed in the up-and-down stream position by just the amount necessary to conceal the effect which was looked for.

That is the plain meaning of the experiment; but we might well hesitate to accept this straightforward interpretation, and try to evade it in some way, were it not for some theoretical discoveries made later. It has gradually appeared that matter is of an electrical nature, and the forces of cohesion between the particles, which give a solid its rigidity, are electrical forces. Larmor and Lorentz discovered that this property of contraction in the direction of the æther current was something actually inherent in the formulæ for electrical forces written down by Maxwell many years earlier and universally adopted; it only waited for some mathematician to recognize it. It would be going too far to say that Maxwell's equations actually prove that contraction must take place; but they are, as it were, designed to fall in line with the contraction phenomenon, and certain detail left vague by Maxwell have since been found to correspond.

We are then faced with the result that a material body experiences a contraction in the direction of its motion through the æther. According both to theory and experiment the contraction is the same for all kinds of matter—a universal property. One reservation should be made; the experiment has only been tried with solids of laboratory dimensions, which are held together by *cohesion*. There is at present no experimental evidence that a body such as the earth the form of which is determined by *gravitation* will suffer the same contraction; we shall, however, assume that the contraction takes place in this case also.

I am going to ask you to suppose that we in this room are traveling through the æther at the rate of 161,000 miles a second, vertically upwards. Let us be bolder and say that that *is* our velocity through the æther—because no one will be able to contradict us. No experiment yet tried can detect or disprove that motion; because all such experiments give a null result, as the Michelson-Morley experiment did. With that speed the contraction is just one-half. This pointer, which I hold horizontally, is 8 ft. long. Now [turning it vertically] it is 4 ft. long. But, you may say, it is taller than I am, and I must be approaching 6 ft. No, if I lay down on the floor I should be, but as I am standing now I am under 3 ft. The contraction affects me just as it did the pointer. It is no use bringing a standard yard-measure to measure me, because that also will contract and represent only half a yard. "But we saw that the pointer did not change length when it turned." How did you tell that? What you perceived was an image of the pointer on the retina of your eye, and you thought the image occupied the same space of retina in both positions; but your retina has also contracted in the vertical direction without your knowing it, so that your estimates of length in that direction are double what they should be. And similarly with every test you could apply. If everything undergoes the same change, it is just as though there were no change at all.

We thus get a glimpse of what, from our present point of view, must be called the *real* world, strangely different from the world of appearance. In the real world, by changing position you extend yourself like a telescope; and the stoutest individual may regain slimness of figure by an appropriate orientation. It must be something like what we see in a distorting mirror; and you can almost see a living-picture of this real world reflected in a polished door-knob.

If our speed through the æther happens not to be so great as we have supposed, the contraction is smaller; but it escapes notice in our practical life, not because it is small, but because from its very nature it is undetectable. And because this real world is undetectable, we do not as a rule attempt to describe it. Not merely in everyday life, but in scientific measurements also, we describe the world of appearance. We do this by imagining natural objects to be placed, not in the absolute space, but in a quite different framework of our own contriving—a space which corresponds with appearance. In the space of appearance a rod does not seem to change length when its direction is altered; and we use that property to block out our conventional space, counting the length occupied by the standard yard-measure as always a yard however its true length may vary. It is found also that in like manner our time is a special time of our own, different from the time we should adopt if our motion through the æther were *nil*. This is a perfectly right procedure; it introduces no scientific inexactness, and it is more in accordance with the ordinary meaning attached to space and time; the only thing to remember is that this space and time framework is something peculiar to us, defined by our motion, and it has not the metaphysical property of absoluteness, which we have often unconsciously attributed to it.

Now let us visit for a moment the star Arcturus, which is moving relatively to us with a velocity of more than 200 miles per second. Consequently its motion through the æther is different from ours, and the contraction of objects on it will be different. It follows that our conventional space would not be suitable for Arcturus, because it was specially chosen to eliminate our own contraction effects. There is a different space and a different time proper to Arcturus. We must then imagine each star carrying its own appropriate space and time according to its motion through the æther. The space and time of one star will not fit the experience of individuals on another star.

The exact relation between the appropriate space and time of one star and the space and time of another was first brought out clearly by Minkowski; it is a very remarkable one. We recognize three dimensions of space, which we may take as up-and-down, right-and-left, backwards-and-forwards. If we go over to Ireland we still have the same space, but Ireland's up-and-down no longer corresponds with ours. The directions are inclined; and what is vertical to them is partly vertical and partly horizontal to us. Now let us add a fourth dimension, imaginary[1] time, at right angles to the other three. There is no room for it in the model, but we must do our best to imagine it in four dimensions. In Ireland the three space-dimensions will have rotated, as I have said; but the time will be just the same. But if we go to Arcturus, or to any body moving with a velocity different from our own, the time-dimension also has rotated. What is time to them is partly time and partly imaginary space to us. It is a change in the space-time world of four dimensions just analogous to the change in the space-world between here and Ireland. That is Minkowski's great result; space-time is the same universally, but the orientation—the resolution into space and time separately—depends on the motion of the individual experiencing it, just as the resolution of space into horizontal and vertical depends on his situation. In Minkowski's own famous words—"Henceforth Space and Time in themselves vanish to shadows, and only a kind of union of the two preserves an independent existence."

From our original point of view it seems very remarkable that in the Michelson-Morley experiment the contraction should have been just of the right amount to annul the expected effect of our motion through the æther. Many other experiments, which seemed likely to show such an effect, have been tried since then, but in all of them the same kind of compensation takes place. It looks as though all the forces of Nature had entered on a conspiracy together with the one design of preventing us from measuring or even detecting our motion through the æther. It is still an open question whether one force, the force of gravitation, has joined the conspiracy. Hitherto gravitation has stood aloof from all the other interrelated phenomena in majestic isolation. We have become almost reconciled to leaving it outside every physical theory. A new model of the atom is put forward which accounts for a whole host of abstruse and recently discovered properties; but it would be considered unfair to suggest that it ought to account for the simple and universal property of gravitation. Dare we think that gravitation has so far forgotten its dignity as to join this conspiracy? There is certainly not enough evidence for a jury to convict; but yet I think we shall have to intern it on suspicion. Recently Sir Oliver Lodge, believing that gravitation was innocent of the conspiracy, showed that a very famous astronomical discordance in the motion of Mercury might be an effect due to the sun's motion through the æther, and might afford a means of estimating its speed. It is difficult in a brief reference to deal quite fairly with an intricate question, but it seems now that we should rather lay stress, not on this single discordance, which can perhaps be otherwise explained, but on the exact agreement of Venus and the earth with theory; for they also should show evidence of the sun's motion through the æther if gravitation had not joined in the conspiracy to conceal all such effects. It may be that the effects on Venus and the earth are not found because the sun's motion through the æther happens to be very small; but on the whole it appears more likely that the effect of the motion is null, just as in the Michelson-Morley experiment, because there is a complete compensation in the law of gravitation itself.

The great advantage of Minkowski's point of view is that it gets rid of all idea of a conspiracy. You cannot have a conspiracy of concealment when there is nothing to conceal. We cut Minkowski's space-time world in a certain direction, so as to give us separately space and time as they appear to us. We have been imagining that there exists some direction which would separate it into a real and absolute space and time. But why should there be? Why should one direction in this space-time world be more fundamental than any other? We do not attempt to cut the space-world in a particular direction so as to give us the *real* horizontal and vertical. The words "horizontal" and "vertical" have no meaning except in reference to a particular spot on the earth. So for a particular observer the space-time world falls apart into its four components, up-and-down, right-and-left, backwards-and-forwards, sooner-and-later; but no observer can say that this division is the one and only real one.

Our idea of a real space more fundamental than our own was, however, not entirely metaphysical; we had materialized it by filling it with an æther supposed to be at rest in it. We now deny the existence of any unique framework of that kind. We have failed to obtain experimental knowledge of such a framework since we cannot detect our motion relative to it. Whatever may be the nature of the æther, it is devoid of those material properties which could constitute it a

*Discourse delivered at the Royal Institution, reported in *Nature*.

[1]Imaginary in the mathematical sense, *i. e.*, involving $\sqrt{-1}$. It is much simpler to consider imaginary time; and throughout the lecture I have ventured to omit reference to the complications which arise when our results are restated in terms of real time.

framework of reference in space. We can perhaps best picture the æther as a four-dimensional fluid filling uniformly Minkowski's space-time *continum*, not as a material three-dimensional fluid occupying space and time independently.

The position we have now reached is known as the principle of relativity. In so far as it is a physical theory, it seems to be amply confirmed by numerous experiments (except in regard to gravitation). In so far as it is a philosophical theory, it is no more than a legitimate and useful point of view. I now pass on to a generalized principle of relativity, in which we must be content at first to be guided by a natural generalization of these results, hoping later to be able to check our tentative conclusions by experiment.

If we analyze any scientific observation, distinguishing between what we perceive and what we merely infer, it always resolves itself into a *coincidence* in space and time. A physicist states that he has observed that the current through his coil is 5 milliamperes; but what he actually saw was that the image of a wire thrown by his galvanometer *coincided* with a certain division on a scale. He measures the temperature of a liquid, but the observation is the *coincidence* of the top of the mercury with a division on the thermometer. If then we had to sum up the whole of our experimental knowledge, we should have to describe it as consisting of a large number of coincidences.

A complete history of the progress of a particle consists of a knowledge of its path and the time at which it occupied each point of the path. The time may be regarded as an extra coordinate corresponding with a fourth dimension, and so the whole history may be summed up by a line in four dimensions representing the particle's progress through space and time. We call this four-dimensional line the *world-line* of the particle. Imagine that we have drawn the world-lines of all the particles, light-waves, etc., in the universe: we shall then have a complete history of the universe. It will be a rather dull history-book; the Venus of Milo will be represented by an elaborate schedule of measurements, and Mona Lisa by a mathematical specification of the distribution of paint; still they are there, if only we can recognize them. I have here a history of the universe—or part of it. Unfortunately I was not able to draw it in four dimensions, and even three dimensions presented difficulties, so I have drawn the world-lines in two dimensions on the surface of a football bladder.

A great deal is shown here which, properly speaking, is not history at all, because it is necessarily outside experience. As we have seen, it is only coincidences—the intersections of the world-lines—that constitute observational knowledge; and, moreover, it is not the place of intersection, but the fact of intersection that we observe. I am afraid the two-dimensional model does not give a proper idea of this, because in two dimensions any two lines are almost bound to meet sooner or later; but in three dimensions, and still more in four dimensions, two lines can, and usually do, miss one another altogether, and the observation that they do meet is a genuine addition to knowledge. When I squeeze the bladder the world-lines are bent about in different ways. But I have not altered the history of the universe, because no intersection is created or destroyed, and so no observable event is altered. The deformed bladder is just as true a history of Nature as the undeformed bladder. The bladder represents Minkowski's space-time world, in which the world-lines were drawn; so we can squeeze Minkowski's world in any way without altering the course of events. We do not usually use the common word "squeeze"; we call it a *mathematical transformation*, but it means the same thing.

The laws of Nature in their most general form must describe correctly the behaviour of the world-lines in either the undistorted or the distorted model, because it is indifferent which we take as the true representation of the course of Nature. That is a very important principle; but, being almost a truism, it does not in itself help us to determine the laws of Nature without making some additional hypothesis. There is one law—the law of gravitation—which especially attracts our attention at this point, and we shall look into it more closely.

We know that one particle attracts another particle, and so influences the history of its motion. This evidently means that one world-line will deflect any other world-line in its neighborhood. Apart from this influence, the world-line runs straight, bending neither to the right nor to the left, provided the bladder is in its undistorted state, *i. e.*, provided we use Minkowski's original space-time. That is not so much a matter of observation as of definition. It defines what we are to regard as the undistorted state, though it is by observation that we learn that it is possible to find a space-time in which the world-lines run straight when undisturbed by gravitational or other forces. I must own that there is a certain logical difficulty in saying that a world-line runs straight when there are no others near it; because in that case there could be no intersections, and we could learn nothing about its course by observation. However, that is not a serious difficulty, though you may be reminded of the sage remark, "If there were no matter in the universe, the law of gravitation would fall to the ground."

[TO BE CONTINUED]

Bird Life of a Big City

By Lee S. Crandall

CITY dwellers frequently are heard to bemoan the scarcity of birds in the vicinity of their homes. It is true that in the more densely populated districts, bird life is represented chiefly by house sparrows and starlings. But even in New York, as one approaches the suburbs, birds increase in variety and numbers. Central Park, most urban of sanctuaries, is famous for the unusual bird which find haven there, particularly during migrations.

The Zoological Park, surrounded on three sides by crowded apartment houses, retains much of its pristine wildness and provides excellent sport for those who hunt with the fieldglass. One hundred and fifty-eight species of wild birds have been identified within our limits, or very close at hand. A number of others doubtless are occasional visitors and may at any time be added, but only those actually observed have been included.

Successful study of birds in the field depends greatly on the season. Many birds which do not nest in the park pass through in spring and autumn, going to or from their breeding grounds. May is the harvest month of the bird student. The spring migration then is at its height and as the birds are in full song and color, they are more readily detected and identified.

After the vernal host has pushed northward, those species which elect to remain with us seek nesting sites. During the process of building, the characteristic songs often indicate the homes of each pair. But after the eggs have been laid and when the young have hatched, the parents become more secretive and their presence may be unknown to all but the most keen-eyed observer.

The return southward after the nesting season has ended is a more straggling affair, and endures from mid-August until November. The males of many species then have lost their nuptial plumage and their songs. Many young birds, generally in the dull coats of youth, are added to the throng. The autumn migration has nothing of the care-free casualness of the spring journey. In October, one comes on a flock of warblers, that in spring might well rival the butterflies in brilliancy of color and grace of movement. Now, in their sombre plumage, they are not easily detected, and only their flitting forms and sibilant call-notes betray their presence. They move rapidly from tree to tree, searching for insects as they go, with a grim haste that is in sharp contrast to their easy-going ways in the pleasant days of spring.

After the last of these travelers has passed southward on its romantic quest, we find the shrubbery and stubble repopulated by flocks of quietly-colored birds, even less obtrusive than those they have supplanted. These are the hardy winter residents, which have come from their northern homes to pass the winter in a climate only slightly less rigorous. It is they that visit our feeding stations, depending on our bounty to eke out the supply of weed seeds and dormant insect life. Thus there is no season when birds are entirely absent, and the persevering observer can always find some reward for his efforts.

In the Zoological Park, we have a still further supply of wild life. This consists of a number of kinds of birds which although not normally included in our fauna, we have successfully colonized at liberty. These are the mallard, black and wood duck, black-crowned night heron, Barbary turtle dove and mourning dove. Occasionally, one is treated to the sight of a pair of Canada geese honking as they pass overhead in superb flight. All of these species are now well established and have become permanent additions to our bird life.—*Bulletin* of the New York Zoological Society.

Remarkable Progress in War Surgery

WHEN it comes to giving the details of the work of surgeons during the last great battle, it will be found that war surgery when considered in general has obtained results which would have appeared incredible at the beginning of the war. At the present time, wounded men are cured in eight to fifteen days, where two years ago they would have passed a long time while under treatment, being transferred from one hospital to another. Patients in which infectious complications would have caused amputation, or even death, are now restored to their original state without any mutilation, and this in a very short time. It may be asked what is the reason for this very striking progress, which allows the French army to recover its slightly wounded men in a very rapid way. The answer is that, after more than three years, surgeons now understand the special nature of war wounds and the proper methods required for their treatment. At the beginning of the war some eminent surgeons believed that war surgery should be the same as what is employed in time of peace. But in this they were wrong, for in war practice were observed the first infectious complications such as tetanos, gaseous gangrene, etc., which were quite unknown in the practice of usual surgery. On the contrary, other surgeons whose counsel was unfortunately followed, considered that if the war wound differed from an ordinary wound, it was because the first was aseptic and sterilized, which is not true for the second case, so that the patient could be successfully treated by removing him to a distance in the rear, taking all the time needed. But it is exactly the contrary that is true, for the war wounds are generally infected by pieces of clothing and projectiles. Experience shows that infectious microbes thus introduced into the flesh only commence to do their harmful work after several hours. The method of transferring the wounded to the rear, such as prevailed in 1914 and 1915, left precisely several hours' time for these microbes to prepare for their action and hence gave rise to very bad consequences. Experience finally showed that surgical practice at the beginning of the war was exactly the contrary to what it should be. Surgeons gradually took up the practice of opening up the wounds even at the quarters situated near the fighting line, so as to hinder the action of the most toxic microbes, such as thrive only in closed cavities, for the presence of air paralyzes them, as shown by their name "anaerobic." To this practice was added the quick extraction of projectiles, thus suppressing the main cause of the infection. Then came the use of the most recent sterilizing substances, such as the Menciere or Vincent solutions, which allow of "throttling" the infection during the few hours which are to elapse before making a more complete operation at a point back of the fighting line. At the present time, and especially at a very recent date, a still more radical method is adopted in quite a number of districts, which follows logically from the present evolution of practice, that is the total removal of the infected parts, followed by a temporary sewing up of the wound. For instance in the surgical establishments at the front, the fresh wounds are now treated by a wide opening up, cutting out not only the foreign bodies such as projectiles, pieces of clothing, etc., but also such tissues as are injured or bruised by the effect of shot, for these after a few hours act as a culture medium for the infection. All this matter is taken out bodily in a single operation, then the wound is closed up temporarily, taking the precaution to watch the progress of the case in one of the establishments in the rear of the fighting line to which the patient has been removed. This method is applied even in the case of extensive bone fractures, such as fractures at the knee or the thigh bone, and it constitutes a marked improvement. When such operations are performed with care, they bring about a very rapid cure of wounds which would have required a long treatment under the methods employed at the beginning of the war. The reason for this great progress lies in the fact that the healing effect acts at a higher speed than that of the microbe infection, and it suppresses the matter which would act to cultivate this infection, so that finally the war wound really becomes comparable to the usual wounds of ordinary surgery.

Effect and Kind of Rust

INVESTIGATION has shown that rust once formed is a factor in the progress of rusting at least equal in effect to those factors universally recognized and is more important than many factors that are subject to dispute because of being attended with detrimental effects of considerable magnitude. It has been found that there is a reversal of polarity according as the rust is wet or dried. As regards rust freshly formed or wet, the underlying iron is electropositive to the surrounding metal, and consequently goes into solution; dried-out rust, on the other hand, assumes a negative polarity, which tends to reverse in time after the rust is thoroughly wet. This observation has a most vital bearing upon the differences observed in rusting under various conditions, and it accounts satisfactorily for the hitherto enigmatical pitting noticed in water pipes. A most important finding is that fresh wet rust does not act as an electrode, but as a semipermeable diaphragm which makes the underlying iron electropositive, and thus promotes its solution, and that the same effects may be obtained by colloidal or sedimentary substances. This fact is of importance in explaining many effects observed in iron pipe or in iron used under water.—*Yearbook of the U. S. Bureau of Mines.*

Photos by American Museum of Natural History
Extensive Aztec ruins discovered in New Mexico

Excavating and restoring portions of the ruins

A Prehistoric Pueblo Indian Ruin

Explored and Restored by the American Museum of Natural History

The American Museum of Natural History, in the summer of 1916, entered upon the largest single piece of scientific excavation ever undertaken in the United States. This was the systematic excavation and reparation of one of the finest and best preserved examples of prehistoric Pueblo architecture in the southwest. The ruin is located in the Animas Valley in northwestern New Mexico, a few miles below the Colorado boundary and directly across the river from the town of Aztec, and is popularly, though inaccurately, called the "Aztec Ruin." It is the property of Mr. H. D. Abrams of Aztec, who has given the Museum a concession to clear out and investigate the entire ruin. The funds for carrying on the work have been generously contributed by Messrs. Archer M. Huntington and J. P. Morgan.

The "Aztec Ruin" was once a typical pueblo, or great fortified house and village, comparable in the number of people sheltered to the modern American apartment house, but differing from it in that the principle of the pueblo was close communal cooperation. The buildings, were so joined as to enclose three sides of a rectangular court, whose fourth side was protected by a low, outcurving wall. Only one entrance led through the outer wall into the pueblo, which was, therefore, easily defended. The three buildings, rising sheer from the ground on the outside, with very small windows, rose within the court by receding steps, each a story high. Interior stairways were not in use, access being gained to upper levels by movable ladders. As a military contrivance, this plan could hardly have been improved upon, since an enemy would be forced to make not one, but a series of attacks, to get possession of the building.

Although the work of investigation has as yet been only partially completed, the features of the ruin itself, and the surprising finds which have been made within the crumbling walls, have proved of sufficient importance to surpass the most sanguine expectations of the investigators. Necklaces of shell and turquoise, agate knives, pottery vessels of varied form and ornamentation, cotton cloth and woven sandals are among the gems of prehistoric Pueblo art which have recently been unpacked in the laboratories of the American Museum. The work has been supervised by Assistant Curator N. C. Nelson, under the immediate direction of Mr. Earl H. Morris, also of the American Museum.

Mr. Morris gives some interesting information about the Aztec Ruin and the relics found there:

Centuries before the landing of Columbus, the ancestors of the present Pueblo Indians reached the highest degree of civilization attained by any aboriginal people of the area included within the boundaries of the United States. One of the richest centers of this civilization was in the valley of the Animas River. There, within a radius of a single mile, vast mounds of earth and fallen stone mark the sites of nearly one hundred community dwellings which once were the homes of thousands of peaceful agriculturists. This is the so-called "Aztec Ruin."

In its original condition the Aztec Ruin was a stately sandstone structure 359 by 280 feet, built around a rectangular court. Its sheer outer walls rose to a height of from 35 to 40 feet, or three stories, on three sides of the rectangle, while the south wing, low to admit sunshine to the court, was perhaps only one story high. There are more than two hundred rooms on the ground floor, and the ceilings of these are still intact. They consist of heavy pine beams placed across the lesser dimension of the rooms, overlain by smaller poles running at right angles to the larger ones and surmounted by a layer of split cedar, or in the more elaborate chambers, by a layer of mats made from willows which were peeled, pierced and strung while green on cords of yucca fibre.

The neatness and precision shown in the construction of this ancient apartment house, for it was that in effect, would have been a credit to workmen equipped with tools of steel, but considering the fact that every timber and each block of stone was cut with crude stone implements, the proportions of the task and the quality of its performance are truly surprising. There was enough masonry in the ruin to have built a wall one foot wide and one foot high half way from New York to Philadephia. Every stone was carried by human beings from the

Courtesy American Museum of Natural History
Remains found in a grave in the Aztec ruins, showing burial customs

quarries three miles distant over a broad road bordered by windrows of cobblestones cleared from the pathway trod by the sandaled feet of the workmen. Broad canals distributed the waters of the Animas River over many miles of the valley, and at the quickening touch of moisture, the loamy soil produced the crops of maize which were the principal food of the Indians.

Each room of that part of the ruin which has been excavated yielded something of interest—perhaps a shell bracelet, some implements of bone or stone, or a pottery vessel—while here and there stones or bits of clay told eloquent tales of tragedy and human devotion. Buried in the corner of one room was the body of a woman carefully wrapped in a mat of plaited rushes. A basket was inverted over the head. In front of the face were a small cooking pot, a food bowl and a drinking cup, while beside the body lay two planting sticks, the blades polished by long use. The right arm had been folded across the breast, and in the crook of the elbow were two stone knives, each of which retained its wooden handle, attached with pitch and sinew. When the breath had departed the relatives of this woman had placed with the body the implements and utensils with which she had planted, reaped and prepared her food, in order that their spirit counterparts might accompany her in the life beyond.

Accident or the hand of an enemy had set fire to the roof of one of the circular council chambers while it was still occupied. Beneath the charcoal and reddened earth of the ceiling lay the partially cremated bodies of one adult and three children, huddled as they had fallen against the walls of the room. Fused to the calcined flesh were the remains of the cotton garments in which the unfortunates had been clad, and over them were mats of rushes which the victims of the conflagration probably drew about them to keep away as long as possible the stifling smoke and searing flame.

Twenty pottery vessels remained as they had been last used, cooking pots around the fireplace, bowls, mugs and dippers resting against the walls and in cupboard-like niches in the masonry. Strewn over the floor were numerous bone needles and stone axes, with now and then an arrowpoint or an ornament of turquoise.

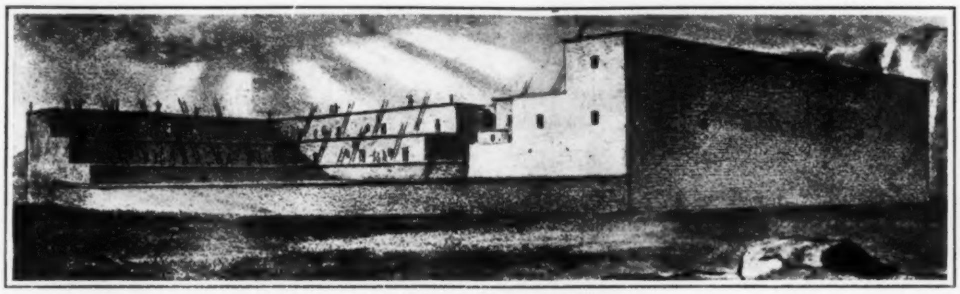
One of the rectangular living rooms had been set aside as a burial chamber. The bodies of two adults and four children were placed in oval excavations in the floor, and with them were a wealth of mortuary offerings. Forty pottery vessels, some of surprising beauty, surrounded the bodies. There were large bowls, their interiors covered with geometric patterns skillfully traced in black on a white ground, bowls and ladles of orange-colored ware ornamented with red and black, vases and water jars, mugs and vessels made in the form of birds. One of these is clearly the representation of a mourning dove.

The beads and articles of personal adornment which came from this room are among the finest which have been found in the Southwest. Abalone shell pendants as large as the palm of one's hand are, perhaps the most conspicuous. Other shell discs of equal size are covered with inlay to produce a pleasing pattern. The central disc, in one case, is a pink stone. Around this are arranged in order concentric rings of turquoise, gilsonite and galena crystals, repeated until the periphery of the disc is reached. The individual elements of the mosaic are worked with admirable precision and are cemented to the shell with pitch. In other instances shells are grooved so as to form a pattern, and the grooves are filled with bits of turquoise which come flush with the surface of the shell.

Strand after strand of marine shells slightly smaller than a thimble surround the necks of the dead, and with them are many ropes of turquoise beads. Naturally the ornaments of shell and turquoise are the first to catch the eye, but from the point of view of craftsmanship the smaller beads are most remarkable. One strand six feet in length consists of 3,100 disc-shaped beads of black stone averaging $\frac{1}{32}$-inch in diameter. It taxes the imagination to devise a possible method of drilling the tiny discs. Perhaps they were pierced with cactus thorn and sand; but be that as it may, the skill necessary to have made them without the aid of metal drills is a record of the patience and ingenuity of the Pueblo artisans.

In other rooms were found cotton cloth, tanned deerskin and a variety of woven sandals ornamented with colored designs.

The 70,000 specimens already recovered from the Aztec Ruin constitute one of the most complete collections representative of a prehistoric North American culture, which has thus far been obtained. Trained preparators are working with the material, and in the near future a representative selection will be placed on exhibition in the Museum's Southwest Hall.


An Aztec pueblo restored

One of the most important phases of the explorations at Aztec is the repair and preservation of the ruin. As fast as the walls are uncovered, masons replace the stones which have disintegrated, and strengthen the portions of the structure which threaten to collapse. The intention is to make of the ruin a permanent monument to the aborigines of the Southwest, rivalling in importance the Mesa Verde National Park. The preservation of the Aztec Ruin is the most extensive and most costly work of its kind which has been undertaken in the United States, and illustrates the generosity and thoroughness characteristic of the American Museum in performing a work of the greatest value in the cause of science and education.

The Golden Apple*

By Sampson Morgan

Over thirty years ago I originated the Fruit Growing Movement, which proved a remarkable success and gave a great impetus to commercial fruit culture on advanced lines.

One of its main principles was the substitution of the dwarf for the standard tree. Simultaneously I initiated the Fruitarian Movement, proving the perfect suitability of perfect fruit for perfect food, in the columns of the London *Echo*.

Then to assure the provision of ample fruit I started a land law reform propaganda through the National Fruit Growers' League, which I founded, with excellent results, the late Mr. W. E. Gladstone commending my work in this connection. Finally, I introduced the new soil science of clean culture, based upon forty years' experiments, by which I have, I insist, conclusively proved that farm manure and all waste animal matter corrupt the soil and interfere with fertility, rendering the production of fruit of perfect tissue impossible.

As the result of my persistent commendation of the apple, it has come right to the front, and has even become of more importance than the orange. Why do I term it golden? Because under proper conditions it puts gold into the pockets of millions of producers, shippers, and distributors, and enables the toiling millions in the cities especially to enjoy the golden prize of health.

In 1911 I was commissioned to select and purchase a quarter of a million fruit trees, bushes, and fruit tree stocks for a gentleman of title, now a well known peer connected with the London press.

They were planted on clean culture lines, and the first year afterward apples 14 inches in circumference were gathered from some of the trees.

For some years, as far as my very limited opportunities and resources would permit, I have persistently experimented with clean culture in various ways, so that if I write emphatically it is because I have ample grounds for doing so. I have grown record crops for four separate products particularly, and this year my experiments with little apple trees have surpassed all previous records, simply because they are older, being now four years planted from the nursery. My plot is quite small, over half an acre. All the work connected with it I do myself, without any outside help at all, and in my spare time. Under these conditions the results obtained are of especial significance.

Much is due to my simple and natural method of pruning, but after all food is the dominating factor, for in every sphere of activity, seen and unseen, the universal cry is: We are what our food makes us. Soils and trees are no exception to that rule. The oneness of the universe is undoubted. It is an organic whole.

It is astonishing what an interest most people take in the apple. The premier fruit planting peer previously referred to above, makes it a daily practice to eat one apple at least all the year through. When perfectly matured, and few on sale in the cities unfortunately are, it is the greatest dainty imaginable, and if clean culture grown, its sugary tissue is easily digested, melting like cream on the palate.

It is rich in wholesome acids, and its juice, pure distilled water of nature, is of priceless worth, acting as it does in the most effective manner upon the earthy accumulations in the system, which are the primal cause of old age and many premature deaths. The tissue and juice of the apple make for health and the prolongation of life, because they make for flexibility. The fresh apple has been found to contain 13.0 of carbohydrates and 8.46 of water; the latter is literally worth its weight in gold when from fruits perfectly matured. The dried apple contains 62.0 carbohydrates, and in this state is richer in such than the much boomed banana. The food value of apples depends upon their sugar contents. It is possible to double this under clean culture ash fertilization. One writer has shown that while some apples may contain 6.83 per cent, the English Golden Pippin contains 10.36. This famous old variety, which a century and more ago was very popular in London, has never been surpassed by any competitor as far as sugariness is concerned.

Is it possible to induce a young dwarf apple tree four years planted from the nursery to produce a bushel of fruit? That was the question I set myself to answer in 1917, and I have demonstrated that it can be done, although the feat has never been accomplished by anyone anywhere.

The fruits have been seen on the trees and counted. I inserted a notice in the *Western Morning News*, while the trees were in fruit, offering to have a photograph taken for anyone free upon payment to the photographer of his charge alone. The actual apples are now on show to the public in several leading cities.

I have experimented with apples for size, color, flavor, sugariness, fertility and keeping qualities. With regard to size and general appearance the results this year have been most marked. I select a few trees and their crops for the purpose of justifying the claims of clean culture.

One of the trees bore 80 yellow skinned apples, most of which weighed 8 ounches. They were cooking apples. Another tree produced 90 handsome red smudged fruits, being literally smothered with glowing specimens, forming, what I do not hesitate to term, the most shapely, fruitful and prettiest apple tree in the world. It turned up quite by accident. It is of continental origin, and I doubt if any expert in the United Kingdom could correctly name it. It caused me considerable trouble to do so.

These two prolific trees form striking object lessons. The former is of British origin. This British apple equalled the continental one in size of fruit and yield. But for prettiness the latter took the palm. I have not yet tested the cooking quality of the foreign sample for it is not yet mature, but I am sure it is perfection.

Though the English specimen is simply splendid, I am perfectly satisfied, however, that if 5,000 bushels of the foreign apples with their glowing red coats were put upon any large wholesale market in Britain they would sell at sight forthwith at good prices. Hardly one of the 90 apples vary in size, shape, or color. The ash fertilization of clean culture greatly enhanced their color.

The following details relate to other trees taken haphazard. On one, on a surface space only of 18 inches by 7, are 22 good sized apples, beautifully colored, growing apparently in one cluster. Several Cox's Orange Pippin trees have from 80 to 120 richly colored fruits.

An early culinary variety 5 feet in height including this year's new growth had 250 apples; 150 were thinned out, and the 60 left on to perfectly mature—the other 40 had been used—are from 9 to 10 inches in circumference.

I have many apples measuring 14 or 15 inches in circumference, although the swelling period has yet six weeks to run. Many Bramley's Seedlings measure 12 inches in circumference. A tree on a surface space of 17 inches by 10 has 17 fine apples, showing an unbroken surface of warm coated King of the Pippins. It has 60 apples even within 32 inches of the ground.

A Peasgood's Nonsuch only 4 feet high, the only one I have, has 26 grand fruits, each from 12 to 13 inches round, weighing on an average 13 ounces each.

What do the records of the trees referred to which bore a bushel of apples each mean, if they mean anything at all? Simply this, that it is possible to obtain these fruits at the rate of 600 bushels an acre, although 75 bushels from such trees would be considered a bumper harvest when fed with manure, though seldom has even that yield been enjoyed.

An Essex fruit raiser claims to have grown 300 bushels of apples from an acre of single cordon trees. I do not doubt it. When this incident came to my mind as I was writing this article, I put my pen aside, and went out and up to the first single cordon apple tree I met. It was in full fruit from top to bottom, carrying 30 late apples, the total weight of which was 7 pounds. These also had six weeks to continue swelling. That is at the rate of 600 bushels of apples to the acre. Until I tested this tree, as the result of writing this article, I was not aware it would give such results. Now these astonishing totals are due to several things, one of which is that with thorough aeration and the provision of bland non-forcing plant food, such as broken-down turf or decayed tree leaves, or leaves of succulent vegetables, such as cauliflowers, or green manuring by ploughing in mustard and such like, together with fine dust of the primary rocks, such as granite, or failing granite dust and a slow acting form of lime, wood, or bonfire ash, we may assure the healthy soil—the foundation of all fertility. From the healthy soil we get the healthy plant and tree; from the healthy plant and tree, the healthy fruit and grain, and these in turn fed to cattle and men assure the elaboration of healthy disease-resistant tissue in the animal organism. Here, then, we have the natural, and because natural true, secrets of health and fruitfulness in the vegetable and animal kingdoms. Without the healthy cell there can be no healthy organism. The cry of all things which live is: We are what our food makes us. In the face of this argument the transcendent importance of the new soil science of clean culture is undoubted.

Soil made up of cloddy lumps of hard clay and lacking humus is useless for fruit culture, although the chemist says that it is rich in plant food. Chemicals will not render it suitable for fruit-tree culture. Without humus it is practically useless. It is the humus which will ameliorate it and enable the cultivator to break down and fine the cloddy lumps, and facilitate the production of that fine tilth which is a vital factor in all productivity.

Humus is produced by the decay of animal or vegetable matter. It is the great nitrogenous principle in soils. In turf of parks or prairie pastures we have the most perfect form of plant food known, and it consists of mineralized humus, the last word that can be said in plant foods and fertilization.

With it any and every crop can be raised in profusion. Its carbon, nitrogen, and ash constituent are so deftly blended together that I question if the wit of man is capable of equalling, much less of surpassing it, in all round effectiveness.

Dead animal material and animal waste matters degrade the earth by fouling it, and in time induce soil sourness which is detrimental to the nitrifying or good soil organisms; that is, organisms good from the point of view of the cultivator and consumer.

Soil fertility is best maintained by supplies of plant food in the form in which it is furnished in turf. The growers should place greater reliance upon labor than upon manure and unduly forcing artificials, which are of a disease engendering nature, if they wish to enjoy bounteous harvests of golden fruits and grains.

The Chemical News.

Animal Camouflage

Examples of the ways in which animals are equipped to hide themselves either for their protection or to enable them to catch their prey were given at the Royal Society of Arts, in a lecture for children on animal camouflage, by Captain P. Chalmers Mitchell, Secretary of the Zoological Society of London. "I don't know anywhere in the world," he said, "where there is such wild and brilliant coloring and bright patterns as among the fish at the bottom of the sea. That is because it is not seen there, and you often find more brilliant patterns on the inside of animals than on the outside." Wherever colors could be seen, animals had as little color as possible to enable them to hide themselves and do their best to resemble their background, and in many cases patterns on animals, which were extremely conspicuous out of their proper surroundings, helped to make their owners invisible under normal conditions. This was shown in the case of the spotted deer.

Exhaust Valve Troubles

A Report on an Important Aeronautical Problem

As a result of trouble having been reported on several occasions by the Services through the burning of exhaust valves of aero engines, Messrs. Rollys-Royce, Ltd., have carried out a series of experiments to determine the cause and to obviate, if possible, the recurrence of this trouble. The following notes are based on their report. A particular instance of this trouble having been experienced on an aero engine after a few hours' run was brought to the notice of Messrs. Rolls-Royce, Ltd., and a thorough investigation was carried out by them without the engine having been interfered with in any way. It was ascertained that the seating of the valve in the cylinder was true, the tappet clearance was correct, and that the analysis of the steel was satisfactory. Rolls-Royce, Ltd., however, claim to have proved conclusively that the valves had burnt through preignition arising from the ignition plug.

The firm hitherto have submitted their engines periodically to rigorous tests of long duration on their testing tackle, and in all these tests no exhaust valves have burnt. They had assumed that the conditions of these tests were more adverse than Service conditions, and therefore were rather at a loss to understand the occurrence of this trouble under normal flying conditions. They have also examined repair engines that have run in service up to 200 hours without the valves having been changed or their condition impaired. A number of further tests having been carried out specially by the firm, they believe that the following information resulting from these investigations will prove of value and eliminate mistaken impressions at present held as to the causes of exhaust valves burning.

Temperature of Exhaust Valves.—It was found that the temperature of an exhaust valve in the hottest portions is 700° C. to 750° C., and that the temperature of the exhaust gases in the exhaust port is approximately 700° C.

Effect of Different Mixtures on Temperature.—It was found that the valve is hottest when the cylinder is working with the most efficient mixture: that is to say, when the maximum power is obtained with the minimum amount of petrol. Whether the mixture be weakened or strengthened from this point the temperature is immediately reduced. When the mixture is weakened the power immediately drops; but the mixture can be strengthened considerably without any loss of power. The general impression that weak mixtures cause the valves to get very hot was not borne out by these experiments. It was apparent that the effect the mixture has on valves burning is controlled by the amount of free oxygen in the exhaust. With a correct mixture there is a certain percentage of free oxygen in the exhaust, whereas with a slightly stronger mixture this does not occur.

Chromium and Tungsten Steels.—Chromium steel possesses the advantage over Tungsten steel that it does not oxidize at ordinary working temperatures. The disadvantage in the use of Tungsten steel is that in ordinary conditions the valves scale and gradually get thinner. Once the valve reaches the temperature at which burning commences, however, the difference between Tungsten and Chromium steels is not appreciable.

Effect of Various Tappet Clearances.—The tappet clearance is, of course, directly affected by the elongation of the valve at normal working temperatures. Tests carried out showed that this elongation is .014 inch to .016 inch. A set of valves were run with no clearance at all in the tappets when cold, so that at normal temperatures the exhaust valves did not seat by .015 inch. The engine ran for 25 hours and the valves were in perfect condition when the test was finished. It was noticeable while the engine was running that the valves were the same heat all over, whereas in normal working conditions they are cooled on the seating where it comes in contact with the cylinder. It was found that it was possible to run with the valves not seating by as much as .008 inch and still obtain a cooled ring round the outer ridge of the valves. It is assumed that in this case the valve is cooled by the thin volume of gas passing around the valve at a considerably reduced velocity and itself being cooled by contact with the seating of the cylinder. Investigations showed that with no tappet clearance in the exhaust valves when cold the power was reduced by 1.5 per cent, and further, that it was possible to run with only .005 inch clearance with no loss of power. In carrying the tests still further, the tappets were adjusted so that the exhaust valves could never seat when cold by .01 inch. As a result the power was reduced by as much as 15 per cent, and the exhaust valves became excessively hot. In these conditions it was distinctly noticeable that the valves were hottest on the outer ring and cooler towards the stem; this, of course, being the converse of the results with correct tappet adjustment. This test also revealed another interesting point in that the valve was found to be much hotter on the sector towards the top center of the cylinder. This is of particular interest, because when burning occurs in an exhaust valve it has apparently never been appreciated why a bite is taken out of one portion leaving the rest of the seating in fairly good condition. During these experiments it was noticed that this bite always occurs on the sector just mentioned towards the top centre where the valve gets hottest. In conjunction with this it was also found that if a valve is turning round while the engine is running it takes a very much longer time to start to burn. Immediately burning commences the valve ceases to turn.

Distorted Valve Seatings.—To reproduce the conditions of an engine running, with distorted valve seatings, the valves were filed away on the angle of the seating. Two were made so that a feeler .005 inch thick could be inserted between the valve and the cylinder seating; another two were made with a clearance of .008 inch and a further two with .012 inch clearance. The engine fitted with these valves ran for 15 hours. On the completion of the run the valves were examined and a slight burning effect was noticeable where the valves were not bedded, but the results were nothing like those indicated in the reports received from the Services. The firm considers, therefore, that the slight distortion that may occur in valve seats is not the cause of the valve burning.

Effect of Pre-Ignition.—It was ascertained during the investigation that with a sparking plug which pre-ignites it was possible to burn either an F.A.S. or a "quick step" valve in from six to eight minutes, and a number of valves were actually burnt out in this time during the tests. An attempt was made on a 6-cylinder engine fitted with "Eagle" cylinders to imitate the conditions of a pre-igniting sparking plug. For this purpose one magneto was correctly timed and the second one connected up in such a way that it could be fired in any position up the stroke, this enabling the operator to produce pre-ignition at will. It was found, however, that the desired conditions could not be produced in this way, the actual conditions resulting being quite different to those where pre-ignition is due to an overheated plug. Pre-ignition was obtained which considerably reduced the power, without, however, producing the excessive heat. A further test was made by using a coil and having a continuous spark on the plug, in the expectation that this arrangement might reproduce the effect of an overheated plug, but again it was found that it was not possible to reproduce the actual conditions arising from an overheated plug.

A sparking plug which pre-ignites under ordinary running conditions causes the exhaust valve to run at an incandescent heat, at which it is amazing that the valve stands up at all. It was found that pre-ignitions are greatly influenced by the amount of lubricating oil in the combustion chamber. The firm claims that a case of pre-ignition in an over-oiled cylinder has never been known, and it was proved by actual experiments that if a plug commences to pre-ignite, this can be remedied immediately by syringing a little oil into the air intake. It was also proved by watching the temperature of the exhaust valve it is possible to inject a certain amount of oil without affecting the horse-power of the engine, but that does reduce the temperature of the valve.

Effect of Faulty Water Circulation.—It was found in the course of the tests that the water circulation has a very big effect on the overheating of exhaust valves. It was noticeable that if the water circulation is faulty the first part to be affected is the exhaust valve. By watching an exhaust valve when the engine is running it can be clearly observed that as the circulation fails the valve gets hotter and even the exhaust bend and guide get to a dull red heat, although there may be still a certain amount of water circulating. If the failure of the water circulation causes the sparking plug to pre-ignite, which is a natural consequence, the valve is burnt in a few minutes.

Summary.—From the results of the above investigations and from the information obtained from the Services, Messrs. Rolls-Royce, Ltd., consider that the burning of exhaust valves is due to two causes: (1) Failure of water circulation; (2) Pre-ignition. Of these it is thought that (1) is more frequently the cause of the trouble, in addition to which it may set up condition (2). The firm base their reasons for this opinion on the fact that complaints of burnt valves are always more frequent in the summer months, and that the squadrons that have most trouble are those in which it is known that the water cooling of the engines is not very good. They do not remember hearing at any time of a valve being burnt on an F.E.2.D. machine, although these particular machines were fitted with an Eagle Series 1 engine having very thin valves made of Tungsten steel which, in the light of the firm's experiments, should have given more trouble than later series. At a later date Eagle engines of a more recent series were fitted into the above machine, but again no trouble was experienced in the way of burnt valves.

The firm's opinion is that, when the water circulation tends to fail, the water commences to boil, and, consequently, water is lost through priming and evaporation, a trouble that it has not been possible so far to obviate. As the engine continues to run the conditions get worse, and in the hottest part, namely, that portion of the water jacket round the exhaust valve, steam is generated which tends to force the water out in the front, and consequently exerts a pressure against the water pump, which still further reduces the flow. By this time pre-ignition starts, the power drops, and the valves commence to burn.

Messrs. Rolls-Royce, Ltd., affirm that pre-ignition should not occur in Service if reasonable care is taken. The chief reason for its occurrence is, in their opinion, that the engine is run with the oil too cold, which reduces the quantity that escapes from the bearings, and so in turn the quantity that reaches the pistons. As a result, conditions are set up that considerably increase the tendency to pre-ignite. The firm fully realize, of course, that occasionally a faulty sparking plug is found which pre-ignites and cannot be controlled. Messrs. Rolls-Royce, Ltd., conclude, therefore, by pointing out that at present the exhaust valve acts as a "safety valve" for overheating, and that it would be very much more disastrous, if, for instance, the piston failed first. A burnt exhaust valve does not prevent the pilot getting home, and the part is easily replaced; they, therefore think that when overheating takes place the exhaust valve is, perhaps the best part on which failure should occur. They state that very encouraging results have been obtained by increasing the flow of water per minute through the cylinder jackets. Further experiments in this particular direction are now being carried out by the firm. The firm state that radiators and radiator piping offer by far the greater resistance to the flow of water, and any resistance in these should be very carefully avoided. It is quite possible that any foreign matter, other than pure water, may tend to increase the resistance through the radiator and hence cause the water to boil through reduced circulation. The priming which naturally follows would soon complete the failure of the cooling system.—From the *Auto Motor Journal.*

How to Economize Coal

The scarcity of coal last winter and the recent warnings of the fuel administration regarding the possibility of a shortage next winter emphasize the need for greater economy in the use of fuel. The present high rate of production is still insufficient to supply all needs and there seems to be no possibility of an increase in the output of the mines sufficient to satisfy every demand.

There are two possible results of this fuel shortage; either certain industries must close down or more work must be done with the coal available. The Engineering Experiment Station of the University of Illinois has just issued a 90-page booklet which shows that the average small power plant can save 15 per cent of its fuel by the exercise of greater care in equipment and operation. This means a saving of twelve or thirteen million tons per annum if applied throughout the country.

The purpose of the publication, the title of which is "Fuel Economy in the Operation of Hand Fired Power Plants," is to present to owners, managers, superintendents, engineers, and firemen certain suggestions which will help them in effecting greater fuel economy, and in determining the properties and characteristics of the coal purchased. Features of installation essential to the proper combustion of fuel are discussed, the practise to be observed in the operation of the plant is outlined; and the employment of simple devices for indicating conditions of operation is prescribed.

The publication was prepared by a special committee of the research staff of the Engineering Experiment Station assisted by an advisory committee.

Only a limited supply of copies of this publication is available for free distribution. Requests for copies should be directed to the Engineering Experiment Station, Urbana, Illinois, and should specify "Circular No. 7."

War Bread

By Edmund I. Spriggs, M.D. Lond., F.R.C.P. Lond.

MUCH has been written about the alterations in the look and the taste of our daily bread which have taken place in the last three years. With better knowledge and practice in mixing flours and making bread there is an undoubted improvement in the loaf in those parts of the country from which most complaint came. There are still, however, many people who believe that war bread is bad for them, and a large number who, while admitting that it may be good for healthy folk, think that it is unsuitable for the sick. It may, therefore, be of advantage to review afresh the composition of war bread at the present moment, to inquire what evidence there is of its digestibility in health and disease, and to consider what profit the nation gains by its use as compared with that of the pre-war wheaten loaf.

The war bread of today is made from flour which consists for the main part of wheat so ground as to yield 90 per cent of the grain as flour. This means that some of the branny material of the outer part of the wheat grain, which was formerly separated and used for feeding animals, is now ground up fine and added, with the germ, to the flour. With this 90 per cent wheat flour is mixed a variable proportion, usually less than one-fifth, of flour made from other cereals, chiefly barley, rice and maize.

We may consider in what degree, if any, the digestibility of the bread is affected by the inclusion, first, of a part of the finely ground bran, and, secondly, of the flour of other cereals.

EFFECT OF INCLUDING LARGER PROPORTION OF GRAIN

A good deal of work has been done in the past upon the advantages or disadvantages of grinding into flour a larger or smaller proportion of the wheat grain,[1] the main result being that the differences in nutritive value of the flours so obtained are not great, not, indeed, so great as the differences between flours made from varying samples of wheat. Judging from earlier work, therefore, we should not be surprised to find that a 90 per cent flour might contain as much nourishment as many samples of 70 per cent or 80 per cent flour.

Recently the Food (War) Committee of the Royal Society[2] has, in a well conceived and wide research, compared the digestibility of 90 per cent flour with that of 80 per cent flour. Observations were made upon four persons in London, four in Cambridge, and four in Glasgow, the diet being regulated and the excreta analyzed. The experiments were directed in the different centers by Mr. J. A. Gardner, Professor F. G. Hopkins, and Professor Noel Paton respectively, assisted by skilled workers. The results showed that the "90 per cent" bread was well digested, 94.5 per cent of the nutritive matter of the whole diet being made use of by the body. With the "80 per cent" bread, 96.1 per cent of the food consumed was absorbed. These figures are averages of all the experiments. There was, however, a striking agreement in the figures from each individual. The proportion of the nitrogen absorbed from the food was 87.3 per cent with the 90 per cent flour, against 89.4 per cent with 80 per cent flour.

This research shows that the addition to the flour of the extra 10 per cent from the outer part of the grain had only a slight effect upon the digestibility of the diet, the absorption being within one or two per cent of what it was with 80 per cent flour. The subjects of the experiment were of varying physique, and they ate rather more bread than they were accustomed to take. When allowances are made for such alteration in diet it may be said that the only notable effect of the bread was an increase in the bulk of the motions. One subject who said that brown bread had always disagreed with him, suffered from diarrhœa, and the experiment was discontinued. He recovered on bread made from Government regulation flour. This subject was the only one of the 12 who took beer, and the thought suggests itself that it would have been of interest to have gone on with the experiment and discontinued the beer.

These observations are in accordance with experience in Switzerland, where an 87 per cent flour is now used. Professor E. Feer has recorded that the bread has produced no digestive disturbance in the children in a large hospital, and that when wholemeal flour was added to the milk of hand-fed children from the third month instead of white flour, no difference could be observed in the nutrition of the children or in their excreta.[3]

EFFECT OF ADDITION OF OTHER CEREALS

The dilution of wheat flour with other cereals would not be expected to have an adverse effect upon digestibility. There is none of the cereals which are available—namely, barley, rice, maize, and oats—which is not, or has not been, the staple food of whole nations.

Two experiments on the point have been published recently. The writer and Mr. A. B. Weir compared in a young man the digestibility of white bread and war bread with breads made from two-thirds white flour and one-third oats, barley, maize, or rice.[4] The subject took a fixed diet, each bread being eaten with it for three days at a time, and the excreta were demarcated and analyzed. All these breads were found to be palatable and were as nourishing as bread made from white wheaten flour, 95 to 96 per cent of the total nutriment being absorbed in each case.

In its newly published report the Royal Society Committee records observations on the digestibility of bread made from four parts of 80 per cent wheat flour and one part of maize flour. The bread was eaten by 17 people, of whom 12 were also the subjects of the experiment with the 90 per cent wheat flour. Of the five new subjects four boys aged 8, 9, 12 and 13, and one was a man of 55 of poor digestion. At one center the subjects did not find the maize bread so easy to eat as that to which they were accustomed, and some complained of flatulence. At another center flatulence was not noticed, and one subject ate 2¼ pounds of the bread daily without discomfort. The analytical results of the observations were in no way dubious; they showed that the bread was as digestible as that made from wheaten flour.

In a further study under the direction of Mr. Gardner breads made from four parts of 90 per cent wheat flour and one part of a mixture of barley, maize, and rice, also of barley and rice alone, were eaten by 47 munition workers for one or two months. The workers were weighed each week and their comments recorded. There was an average increase of weight. No flatulence or diarrhœa was complained of, and some of the workers who had suffered from constipation, and one who was liable to diarrhœa, were better while taking the bread.

We may, therefore, conclude from all these observations that the dilution of wheat flour with other cereals in the proportion hitherto used is in no way harmful. The use of potato in bread was not investigated in these experiments, but it may be assumed safely that such bread also is well digested. Indeed, much of it has been eaten with appreciation and without complaint.

NATURE OF COMPLAINTS

The symptoms which are most commonly mentioned and attributed to war bread are a feeling of fullness, flatulence, looseness of the bowels, or constipation. It may be noted in the first place that a feeling of fullness and flatulence are the two commonest symptoms of indigestion of all kinds. They are likely to occur with any change of food, from dietetic errors unconnected with bread, from overwork or many other causes, and are not of consequence unless they persist. In view of the experimental data given above it appears that such symptoms cannot be ascribed to indigestibility of the ingredients from which war bread is made. If they arise from the bread at all they are more likely to be due to unskilful baking or insufficient chewing. War bread makes good toast, and for some types of weak digestion it is an advantage to toast it, as was, indeed, the case with pre-war bread. The second complaint made is of mild disturbance of the bowels, chiefly looseness, though some of the subjects of the experiments with maize bread complained of constipation. On the whole, war bread appears to be a little laxative as compared with pre-war bread. This is probably an advantage to the nation. Constipation is, unfortunately, too common on the modern diet of civilization, and is in many people a source of ill-health.

The Royal Society's report gives some observations in which the same bread as was supplied to the canteen above referred to was eaten by 25 patients, including some advanced cases, observed by Dr. G. B. Dixon and Dr. E. G. Glover, in two sanatoria. Three of the patients disliked the bread and preferred ordinary bread, but in none was there evidence of digestive disturbance. War bread has also been eaten by patients with many forms of indigestion without any complaint being made that was not made with white bread. Experience shows that the number of those who complain of war bread includes a good proportion of nervous folk who would in any case be complaining of something. Indeed, Professor Feer says that in Switzerland only neurasthenics and hypochondriacs complain. We do not go so far as that, for we recognize at least two other classes of complainers. First, those already mentioned, who ascribe to a particular article of food symptoms due to other causes; and, secondly, those who do not like war bread and confound their likings with their needs. Members of our profession, when consulted by those in the last class, may justly call attention to the following facts.

BENEFITS FROM USE OF WAR BREAD

Since a great part of our cereals comes from abroad the delivery of bread to each household involves the buying of corn abroad and its transport to this country. Such corn has to be paid for in money or in credit, and each payment lessens our wealth at a time when every penny is needed to help us in our struggle. But more than that, wheat brought across the sea involves at the present time a loss of ships and of our sailors' lives, owing to the frequent sinkings by submarines. The use of homegrown cereals to dilute wheat flour reduces these losses. A further reduction is made by grinding all the wheat to a 90 per cent standard, for this alone, as the figures of the Royal Society's Committee show, gives a gain of 10 per cent of nourishment, and even when allowance is made for the use of millers' "offal" to feed animals, there is still a gain of 9 per cent of nourishment. That is to say by using war flour we save at least one pound in each 11 that are spent, one wheat-ship in each 11 sunk, and one life of each 11 that are sacrificed to give us our daily bread.—*The Lancet.*

[1] See J. M. Hamill: On the Nutritive Value of Bread made from Different Varieties of Wheat Flour, published by H. M. Stationery Office, 1911.

[2] Report on the Digestibility of Bread (3206).

[3] E. Feer: Ueber die Verwnedung des Vollmehls in der Sauglingsernahrung, und uber das Vollbrot im Allgemeinen. Corresp. f. Schw. Aerzt., Dec. 29th, 1917. Quoted from the *Lancet*, March 9th, 1918, p. 379.

[4] E. I. Spriggs and A. B. Weir: The Digestibility of Bread made from Two Parts of Wheat and One Part of Oats, Barley, Maize, or Rice, *The Lancet*, Nov. 10th, 1917.

Oil Seeds and Vegetable Oils

THE seeds of the various species of *Bassia* which occur in the East Indies yield fats suitable for edible purposes, and are now imported into Europe under the name of Mowra seeds. In India the fat is expressed from the kernels of these seeds and eaten. There is a considerable difference in the amount of fats present in the various species of *Bassia*, the *B. batyracea* being the richest, then comes the *B. Longifolia*, while the *B. latifolia* is the least rich in this respect. Of the two species last mentioned, large quantities of kernels are exported from India, while there is at present practically no export of the first species. The exports of Mowra seed from India in the year 1916 were 5,130 tons, valued at $156,150. Another product from this region is Niger seed, and the oil is used as a substitute for linseed oil when the latter is scarce, though it possesses inferior drying properties. It is also suitable for soap making and for use as an edible oil. The cake has been used as a cattle food with satisfactory results. From poppy seed an oil is obtained which is largely used for culinary purposes in India. This oil is also suitable for mixing with paints, and the inferior grades are used for soap making. In normal times, there is a large export of poppy seed from India to various European countries; for 1916 this figured $274,390. Sesamum seed, also known as sesame, sim-sim, til, gingelly, and benni-seed, is the source of a valuable oil which is used as an article of food in the countries where it is produced, and is also extensively employed in European countries for soap making and in the manufacture of margarine. The plant is cultivated in all the warmer countries of the world, but the chief sources of the seed imported at Marseilles, which is the most important European market for this product, are India, China and Turkey. Shea nuts and shea butter may also be mentioned among colonial products. Shea butter, or the fat obtained from the kernels of the shea tree of West Africa, is used by the natives of West Africa for food, and to some extent as a burning oil. The high melting point of the fat renders it specially suited for the manufacture of candles. Mixed with other oils it is used for soap making. The shea butter tree flourishes over large areas in Northern Nigeria, and is also widely distributed over the Bole district, Gold Coast, where the natives make use of it on a large scale. Were transport available, a considerable trade might be done in this valuable product from the Gold Coast. The shea butter produced in Ashanti is so far nearly all locally consumed. The quantity produced, therefore, remains about stationary, but vast supplies exist in the north that have not yet been exploited, for the shea nut trees cover large tracts of land in this region. The soya bean of Manchuria has long been an important article of food in the East. In Europe the oil pressed from the bean is used by manufacturers of margarine, soap and candles, in the manufacture of varnish and printing ink, and for waterproofing umbrellas. Soya bean meal is also stated to be used in making bread on the Continent. Beancake has long been used in making bread on the Continent. Beancake has long been used as a fertilizer and for feeding stock. Experiments in growing soya beans have been made in practically every British colony, but it seems unlikely that the product could be profitably grown for export in competition with the Manchurian beans, which are raised under ideal climatic conditions and by the cheapest possible labor. Imports of soya beans into Great Britain for 1916 show 71,900 tons, valued at $4,801,000.

Operating gang drill presses

A large shop where shell billets are formed

Women in British Munitions Factories

Work Behind the Lines as Important as Service at the Front

On numerous occasions reference has been made in these columns to the employment of women in manual labor abroad which has heretofore been performed entirely by men, and although we, in this country, are rapidly becoming accustomed to the same condition it so far has not become so general as in either England or France, where in many factories, especially those devoted to the manufacture of munitions, the proportion of women employed is fully 80 per cent of the total force. As the war progresses, however, and the demands for materials for our armies increases more hands will be required in the factories, and for these we must look to the women, especially as our men will be needed at the front.

To get an idea of the extent of the demands made by the requirements of an army engaged in active warfare, and how rapidly they multiply, a few facts and a few figures may be given of what has been done in England. At the beginning of the war an automobile factory undertook to turn out 1,800 shells of 9.2 diameter each week. Today the same shops, greatly enlarged, are producing 50,000 shells per week. During the Boer war another company was making 2,000,000 rifle cartridges a week, but at the opening of the present campaign they undertook to get out 25,000,000 a week, and this quantity has since been considerably increased. Practically the same conditions prevail in France, and we, in this country must expect to duplicate such productions, and probably to exceed them as time goes on.

A noticeable feature of the women workers in England is that they are by no means drawn exclusively from the classes who previously worked for their living, but include very considerable numbers from the ranks of the well-to-do, who have taken up the work from patriotic motives; and it is these women of education and intelligence above the average who have made the experiment so successful, and who have made the outputs above noted possible.

When women are employed in factories in such large numbers special conditions must prevail, and special provisions made, without which success is impossible. A consideration of this subject will be found in a paper that recently appeared in these columns, which should be carefully studied by everyone proposing to introduce the employment of women in factories.

The accompanying illustrations show views taken in British munitions factories where women are employed, and it will be noted that, besides light mechanical operations they are apparently also engaged in the work of forging shell billets; but it would seem that such employment can hardly be desirable, on account of the physical exertion necessary and the heat to which they are necessarily exposed, and it is undoubtedly true that the occupations where they may be employed to the greatest advantage are of the lighter kind where deftness of hand and quickness of eye count most.

It must not be assumed that, because such great numbers of women are entering the mechanical trades during this period of stress, that they will entirely replace male labor, for, although many clever operators have been developed from among the ranks of the women, the number who possess the mechanical instinct necessary for successful results in the more technical and intricate branches is quite limited. Moreover, skill in numerous kinds of machine work can only be acquired by many years of experience, and at that it is not every man that develops the necessary qualifications for producing the highest class of work.

This is a matter that is receiving close attention now by the different governments, for, at the commencement of the war, when there was urgent need for building up the armies as rapidly as possible, men were drawn indiscriminately from every occupation. It was soon realized, however, that many men in the ranks were of far greater value at home in the work of making war material

Milling gun parts

than they were in the trenches, and that the factories were being crippled because there were too few operatives left who were capable of the finer mechanical operations. This was due partly to the necessity for assembling great numbers of men in the shortest possible time, and partly to the lack of appreciation of practical manufacturing requirements by officials; but more careful attention is now being given to this phase of our war preparations, although not yet in as systematic a manner as is desirable.

Finishing the nose of a large shell

An instance of official ignorance, although in this case it may well have been official treachery, occurred in Petrograd a couple of years ago. The draft officers called out the entire force of a factory engaged on important munitions work, thus causing a complete suspension of production. Vigorous protests and explanations were made, and finally, after protracted discussion, the officials sent a force of men to the factory. They were not, however, the men originally taken, but the first that were conveniently found—peasants, tradesmen and a miscellaneous collection of unskilled labor that was absolutely incapable of continuing the work. It was such performances as this that sent great masses of men to the Russian front, entirely unequipped, and left them to meet the enemy with their bare hands.

We have seen the disasterous results of such lack of forethought in the utter disorganization of the Russian army, for nothing is more demoralizing than the failure to keep troops adequately supplied with munitions and materials, and the delay of half an hour in furnishing ammunition will often decide the fate of an important battle.

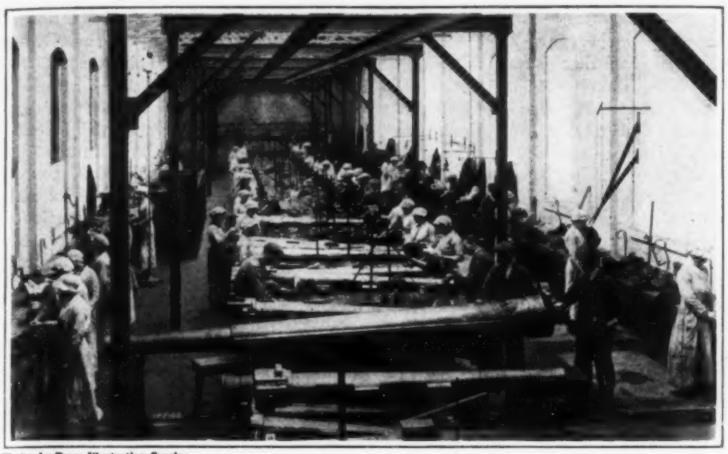
Soy Beans Make Valuable Food

While the soy bean has been grown in the United States primarily as a forage crop, its availability as a valuable food for human beings is being given increasing attention. Many schools of cookery and domestic science in this country, as well as home economics experts and home-demonstration agents of the United States Department of Agriculture, have shown that dried beans can be used successfully in the same manner as navy beans. The variety and palatability of the ways in which the beans can be served make them a desirable article of food.

When prepared like the ordinary field or navy beans, the soy beans should be soaked for 10 or 12 hours or more, if necessary, and boiled slowly. The boiled soy beans, like boiled navy or field beans, may be seasoned and used as the principal part of a meal, as they are or may be made into bean loaf, bean croquettes, or other dishes.

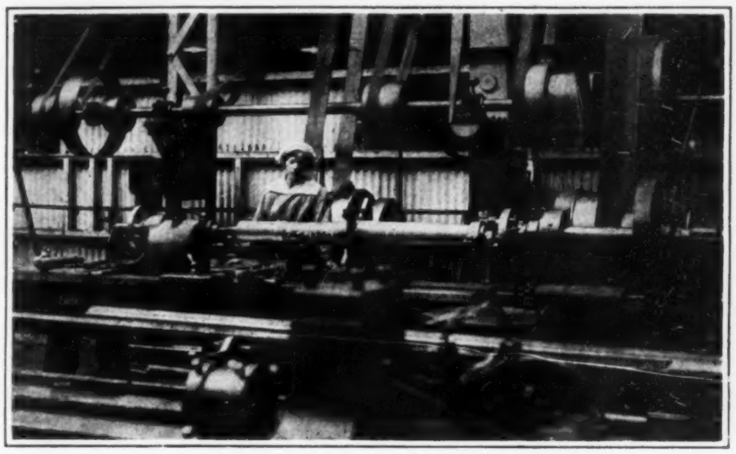
When soy beans are three-fourths or more grown, the seed make a palatable and nutritious green vegetable.

If the dried beans (yellow or yellowish-green varieties) are soaked for a few hours then finally crushed (as in a meat grinder) and boiled in three times the amount of water as of bean material for about 30 minutes, a milky emulsion is obtained which is similar in appearance and properties to cow's milk. The addition of either magnesium chlorid or calcium sulphate (about a 1 per cent solution) to soy-bean milk precipitates some of the proteid substances, forming a grayish-white curd which settles out, leaving a yellowish watery liquid. This curd, after being drained and pressed, represents the tofu or bean curd extensively eaten in China and Japan. Soy or shoyu sauce is a dark-brown liquid prepared from a mixture of cooked and ground soy beans, roasted and pulverized wheat or barley, salt, and water, inoculated with a culture known as rice ferment and left in casks to ferment for six months to a year or longer. The liquid obtained is used in many countries, including the United States, as a sauce for meat or vegetables.—Weekly News Letter of the Dept. of Agriculture.



Photos by Press Illustrating Service

Fitting gun breach mechanism



Turning a gun tube on a large lathe

Daylight Seeing

By William H. Pickering

As a result of correspondence with some astronomers who were interested in observing the Sun, it occurred to the writer that it would be desirable if possible to prepare a separate Scale of Seeing which should be applicable to daylight observations. At present there is no generally recognized scale suitable for this class of work, each astronomer estimating the quality according to his own personal impressions. There is therefore no means of properly comparing the seeing at one season of the year with that at another, or of determining whether the conditions at a proposed location are better or inferior to those at already established stations.

The Zenith Equatorial is so convenient an instrument to handle, that it seemed to be the ideal device with which to undertake an investigation of this sort. It was soon found with it that the stars are not readily available as standards, since even the brighter ones are difficult to find, when viewed in a silvered mirror, and only Arcturus will show the diffraction arcs by daylight. The outer detail on which we depend in the case of the Standard Scale is in general not visible.

The Moon can only be used to advantage between the third and first quarters, and it is then so faint that the identification of the smaller objects on its surface is extremely difficult. Jupiter can be readily found, but is well seen by daylight for only half the year, and is also extremely faint. There remains then only one available object—the planet Venus, but it can be seen practically throughout the year, and is so bright that it is always conspicuous in the telescope. We began an investigation of its appearance this past January, employing our ¼-inch eyepiece. Comparisons were also made with the appearance of the planet in our 11-inch telescope and 3-inch finder. From these observations a Daylight Scale of Seeing has been constructed. It was immediately found that, unlike the Standard Scale, it was affected but little by the aperture of the instrument employed. Indeed the 11-inch gave if anything rather better definition than the smaller instruments. While the images, which had they moved with sufficient rapidity would have given the effect of a blur, in the 11-inch the blur was the only effect perceived. Usually the seeing was marked the same in both the 11-inch and the finder, but the latter was found to give the more certain result, that is to say the scale divisions were more sharply defined with it. After several weeks of investigation it has been decided to define the divisions of the Daylight Scale of Seeing as follows:

1. A constantly wavering image.
2. Limb hazy. Bright supplementary images and blur constantly visible.
3. Limb hazy half the time. Faint supplementary images and blur constantly visible.
4. Limb sharp. Faint blur visible half the time or more.
5. Limb sharp. Faint blur only occasionally visible.

The distance of the supplementary images outside the limb generally lies between 1°.5 and 4°. In a limb described as sharp, the breadth of the blur should not exceed 0°.3, if somewhat blurred 0°.7. These small angles were measured by comparing them with pencil lines drawn upon a sheet of paper placed some twenty inches from that eye which was not used in making the observations. The diameter of the planet was found to be five-eighths of an inch when its angular diameter was 55°. This gave a magnification of 118. The result previously secured from measurements of the foci of the lenses was 120, which gave a satisfactory check on the method. When the crescent is narrow, which is the case for only about a month in every two years, the breadth of the ends of the cusps can be measured. It is found that 0°.3 is about the limiting breadth for a lens of 3.5 inches aperture. In general it may be said that the five numbers of the Daylight Scale indicate possibly a little better seeing than the corresponding ones of the Standard.

It was not found possible in January to examine the planet with the Zenith Equatorial until after noon. The seeing, as was to be expected, gradually improved as the day wore on, until the planet was some 20 above the horizon, when a series of small waves usually appeared along the limb, which previously was perfectly sharp and smooth. Soon after colors due to atmospheric refraction appeared. As a general thing in the daytime our seeing is 3 and 4 as determined by the Zenith Equatorial, and varies but little from day to day, but curiously enough it is appreciably better as measured with the 3-inch finder. This is attributed to the fact that with the former instrument the light, previously to reaching the mirror, passes a few feet above the roof of the house. Although we employ no artificial heat, and there is no means whatever of warming the house, even if we desired to do so, yet it is thought that the wooden shingles may be sufficiently warmed by the sun to start air currents, sufficiently pronounced to interfere with the seeing. With the finder and a power of 180 it is nothing at all unusual for Venus to present a perfectly sharp limb, with the Sun one or two hours above the horizon.

Assembling parts of machine guns

When Venus reaches a more northern declination, which will occur in the spring of the present year, it will no longer be affected by radiation from our roof, and it is hoped then to investigate the matter further, and if necessary to change slightly the present scale of Daylight Seeing, which must therefore be considered for the present as merely provisional.—*Popular Astronomy.*

Safety First for Foundrymen

More than ten years ago, William Sellers & Company, Inc., manufacturers of machine tools, of Philadelphia, Pa., recognizing the growing need of a "Safety First" campaign, in their works, for the education of their employes, commenced to keep systematic records of all accidents occurring in all the departments.

A detailed summary was prepared each year, showing the number of accidents and, at the end of the first six years, an elaborate compilation was made giving the total number of accidents, classified under different headings, with percentages of same and showing the proportion, per hundred employes, of such accidents each year.

The six-year compilation showed that the largest cause of accidents in the foundry was due to "burns on legs and feet" from molten iron splashed from ladles or spurting from imperfectly closed molds.

Inquiries were immediately sent broadcast for any practicable protectors for preventing such accidents. When it was found that none was to be obtained, experiments were at once made by the metallurgist with asbestos cloth and other materials with some surprising results. Boards about one foot wide and two feet long were placed upright at an angle on the floor of the foundry and various fabrics tacked upon them. Molten iron was then dashed (not poured continuously) over these surfaces. It was soon found that closely woven smooth-faced fabrics (though combustible when exposed to a candle flame) shed molten iron like water from a duck's back. Even a sheet of paper was subjected to this "trial by fire" several times without flaming. It was at once recognized that here was a valuable discovery which offered a solution of the problem.

Leggings of special form having a wide cape or extension covering the foot were designed and ordered to be made of closely woven canvas by a large military equipment establishment. The first dozen pairs were received early in 1912 and were put into use in May. The laborers carrying molten iron were at first not ordered to wear these protectors which were supplied free of cost. The idea of compulsion was distasteful to the management but it was pointed out to the workmen that if they neglected to wear the protectors and were burned on legs or feet they need not expect to receive pecuniary assistance.

The protectors are, to this day, worn by all men carrying molten iron in the foundry.

Four years and eight months have now elapsed since the closely woven leg and foot protectors were first put into daily use, and there is yet to be recorded the first case of any man losing any time from burns on legs or feet from splashed molten metal while wearing the protectors, notwithstanding that molten metal has splashed over the protectors countless times. This is a truly remarkable record.—*Journal* of the Engineers' Club of Philadelphia.

Stammering, and the Ladies

By Ernest Tompkins, M.E.

"HAVE you ever known a woman who stammered? It is very doubtful. The fact that those afflicted with stammering are a hundred men to one woman is one of the most curious things in the science of pathology." This quotation from the introduction to an article in *London Answers* is typical of the information given to the public on this mystery of a mysterious disorder—the "exemption" of the women. That this sort of information is not confined to popular publications is evident from the following quotation from a publication of "scientific character," and "ideal purpose," according to its editor-publisher. "The relative immunity of females to stammering is due"—and so on. The fact is that the women are not immune. Let us prove the fact.

Whoever says that the male stammerers are more numerous than female stammerers is making a decidedly partial statement. Two facts we know—for the observations are sufficiently verified to enable us to say we know; the other remains to be proved. We know that the preponderance of male stammerers is great in adulthood, and that it is much less at school age; but what is it in early childhood, of which we have no statistics. That stammering girls are not very rare in school and that stammering women are rare; is so well recognized that it would be superfluous to give many quotations to that effect. Fletcher says, ". . . estimates show that male stutterers preponderate over females in ratios ranging from 2.1 to 10.1. The male preponderance is much greater in adulthood than it is in childhood." Conradi says, "Gutzmann gives 2.1 for boys." Forget the ratios for a minute and notice that last clause, "with girls it is more apt to disappear than with boys." Gutzmann "let the cat out of the bag," for there is nothing which the speech specialist keeps in the bag more sedulously than the recovery of the girls; indeed, most of them flatly deny it. If public attention was not diverted from that recovery it would be applied to all stammerers and then there would be no more stammering business. So the cat is promptly rammed back into the bag and the public is assured, "You saw nothing." We will have to drag it out by the discussion, but the glance is suggestive to those who are not too dense. The unanimity with which this secret is hidden may be judged from the fact that Conradi gives a list of 92 works on the subject of speech which he consulted, and yet says of the sex ratio, "That this difference exists has been observed by all, at least modern writers, but the cause of this difference, an interesting and important question, has not been solved." A careful reader of nearly a hundred books on the subject of stammering could not find in them the most important fact of the subject, the recovery of the girls, its importance and its suppression due to the fact that the extirpation of the disorder depends on it.

Reverting to the sex ratios of stammering, we may take girls to boys in school as 1.3; for Conradi says of the statistics of 87,400 American school children, "1.25 per cent of all the boys stuttered and .47 per cent of the girls, making the ratio nearly 3.1." For adulthood, women stammerers to men stammerers, the generally accepted ratio is 1.9. Accordingly, for nine stammering school boys there are three stammering school girls; and for nine stammering men there is only one stammering woman: two-thirds of the girls or two-thirds of their stammering has disappeared. Why?

In order to be sure of our ground—which is the number of male stammerers—we should first consider that. The facts are that some of the boys recover; but, since many authorities dispute this recovery, and since the argument should be consistent throughout, we will assume that no boys recover. On the other hand, there can be no appreciable increase in the number of male stammerers, for the disorder is not contracted to any extent after school age.

Do two-thirds of the stammering school girls disappear? How could they, except by death? If they were lost the police records would show it; and if they emigrated, the international sex ratios would not correspond so closely as they do. But mortality statistics show that girls do not die off as rapidly as men do; so the disappearance is not that of the stammering girls.

That two-thirds of the girl stammerers recover between school age and adulthood is the inevitable conclusion. Now, will all the immunity and exemption protagionists please listen. Two-thirds of your case is "gone by the board." By the ratios you yourselves give, recovery, and not immunity, is the fact for two females out of three. That recovery must be the explanation for the other one is an impelling supposition, which, for lack of statistics, will have to be shown by deduction. But it should be thoroughly understood that the rest of this discussion is concerned with the one female in three who might not have been immune. At this point two-thirds of the immunity is dead—the other third is sick.

We may ask here why we ever believed in immunity. Just because there are few women stammerers. But that reason is now exploded, so we no longer have a reason for belief in immunity. In good sense there is no more immunity to talk about. However, in many fields and overwhelmingly in stammering, not sense but something else decides beliefs. So we must go on and disprove a belief that has no standing in a scientific discussion.

But was not immunity accounted for by the innumerable theories of stammering? Rather, did not the innumerable theories of stammering justify themselves by accordance with immunity? Yes. They swam or sank together, so they are sunk—those marvelous pieces of scientific joiner work by which the investigator linked his theory indissolubly with immunity, and now immunity gone and theory, too!

Does recovery occur before school age as it does afterward? Yes, and to a greater extent; for the school treatment of stammerers intensifies their difficulty as a rule. This situation is this. Stammering is its own intensifier. The stammerer makes a face that makes his neighbors laugh. The ridicule hurts the stammerer's feelings, and in order to avoid more ridicule he struggles more desperately with his speech the next time, and has more trouble, because the struggle is the impediment. The alleged defects in his brain and nerves exist only in the imagination of his unscientific investigators. Keep the stammerer from struggling with his speech and he can talk as well as anyone. When the struggle for office keeps the stammering politician from struggling with his speech he is perfectly fluent. You can scare a stammerer out of stammering as you can a baby out of hiccough, but the same precaution is necessary; you must scare him enough. If you scare him only sufficiently to bring his impediment to his attention he will splutter and bluster worse than ever; but push him off the dock and you will get a lecture without a hitch in it. However, less heroic distractions prove abundantly that the stammerer is fluent when he does not interfere with his speech; he is fluent in solitude, under suggestion of ability to talk, in concert reading and speaking, and so on.

Since the school treatment retards the recovery of stammering, since most stammering—87 per cent, according to Chervin—is contracted before school age and since no retarding influence prior to schooling has been shown, we must conclude that the recovery of the girls ensues at an even more rapid rate before schooling than after.

The authorities claim that there is some feminine characteristic which makes girls less susceptible than boys to the causes of stammering. Not only does this claim fall down with the theories which supported it, but it is also invalidated by the fact that more than two-thirds of the girls who actually stammered lack that characteristic. Moreover, we know that in some cities the number of girl stammerers even at school age is as great and sometimes greater than the number of boy stammerers. These statistics may be found in the appendix to Denhardt's "Das Stottern."

The claim is also made that girls are not as much exposed to the causes of stammering as boys are, but that would not constitute exemption. However, let us look into the matter. The causes of stammering fall into three general classifications (1) temporarily broken speech, such as follows severe nervous disturbance; (2) imitation, and its near neighbor, association; (3) stuttering (repetition of words). How anyone can validly show diminished exposure of the little girls to these causes is difficult to see. They are certainly subject to nervous shocks. Although they might not experience such severe shocks as their little brothers, still their greater susceptibility to shock would probably make the final result much the same. Girls imitate as much as boys do or more. Association could not be different. And the habit of repeating words has not been shown predominant in either sex. So it is safe to say that girls are as much exposed to the causes of stammering as boys are.

The nature of the disorder should indicate whether immunity or recovery accounts for the scarcity of women stammerers, but the field of stammering is one of such extreme confusion that an investigator seldom enters it without becoming confused himself. How can we give that field its proper weight, save the time which its extensiveness would seem to demand, and yet escape its retrogressive influence? Let those who are in it speak for themselves. Undoubtedly the most progressive of the lot is Professor Fletcher. Since he says, "I think one can safely say that there is no such thing as 'growing out' of stuttering," he cannot be prejudiced in favor of the recovery of the girls, so it is eminently fair to his side to use him as a witness for that recovery. He says of the field of stammering, ". . . there is in the medical world of today little more than a confusion of personal opinions and theories." But he is a layman, and physicians might question his conclusion, so here is the conclusion of Dr. Browning (1915), ". . . there is no generally accepted or even clear explanation of stammering . . . none of the proffered theories has any comprehensive basis of fact." This sums up the question with one exception, which is Dr. Browning's own theory—the last American theory to obtain recognition. How shall we give that its proper weight? He says, "Careful observation shows . . . interrelated conditions . . . such things as adenoids, tonsils, nasal intumescence, enuresis nocturna, general hypotonia with bad bodily carriage (winging scapulæ, relaxation of abdomen, great lombar incurve), shallow upper chest, traces of past rachitis, large eating, palpable lymphatic glands, bronchitis, various forms of habit spasm, cardiac leaks and irregularities, certain stigmata; less frequently, elipeptiform attacks . . . mental or moral insufficiency; and constantly, evidence of large thymus or block in that area." What a nightmare! But it is no more, for Fletcher wakes us up with the illuminating truth, "The subjects are not to be distinguished physically from other people."

But in that quagmire of superstition, guesses, speculation and sunbaked theory, is there no light? Yes, the light is there and always has been; but the people must get it out for the prevailing influences suppress it. Let us get it out.

That there is no consensus of opinion in regard to the nature of stammering is only partially the truth. There is no agreement as to the kind of disease the stammerer is alleged to have; but just as the spontaneous recovery crops out in spite of the influence against it, so the habit nature of the disorder crops out, too. Bryant, Kyle, Reed, Roads and others have unqualifiedly pronounced stammering a habit; and Browning, Scripture, Swift, Bluemel and others pronounce it a habit in connection with the particular disease or diseases which each one advances; but since the disease views conflict and disprove each other, whereas the habit view harmonizes throughout and is readily demonstrable, we have no more choice in the acceptance of the latter than we have in the rejection of the former. Stammering is a habit, and habits are outgrown; so the recovery of the infant girl stammerer is accounted for. The recovery of the other girl stammerers has already been accounted for.

But what kind of a habit is stammering? For that may throw light on the question of immunity versus recovery. If there is a wonder in the world it is that with all the intellectuality in this country there is not enough to see such an evident fact. Will the reader press his lips tightly together and try to talk. He is stammering. He thinks he is merely impeding his speech, but anyone looking at him would take him for a stammerer. Let him do anything which the stammerer does—hold the breath, exhaust the breath, keep catching the breath, press the tongue against the upper teeth or the palate—and he will find that he is impeding his speech. The stammering child acquired that habit in infancy and society has forced it to continue in it. Parents send the little stammerer to answer the door-bell or the telephone call, to meet the stranger or run to the store; teachers make the unfortunate child stand up before a class and try to recite; society at large makes the stammerer introduce people, give his name and address on innumerable occasions, dictate, telephone, speak in public; even the stammering schools and clinics teach him breathing and articulatory exercises which intensify his difficulty after the temporary improvement is passed; and the educational authorities are now doing the same.

But why do the girls generally recover? Their mothers break them of the habit. The cat is out of the bag. It was nearly out long ago, for Conradi says, "Some of the early writers thought that the girls had their errors corrected by their mothers because they were in the house more, whereas boys played on the streets and were not subject to this correction . . ." but this saving truth has been hidden by the confusion which has been cultivated since.

Undoubtedly the little girls contract stammering as extensively as the little boys do. Society has not yet extended to the great class of stammerers the essential justice which it extends to the dumb, the blind, the lame, and even to unfortunate animals; but forces the stammerers to conform to speech conventions which are injurious to them. The environment of the girls affords sufficient protection from that unjust treatment or sufficient counteractive home influence to enable her to escape as a rule. Since there is only one stammering woman to nine stammering men, eight-ninths of the girls recover. If the other ninth of the stammering girls and all the stammering boys had the same treatment, they would recover, also; and if the treatment was begun immediately on the appearance of the disorder, there would be no more stammering. When the press disseminates light on this subject, instead of darkness, that desirable result will be accomplished. Let there be light.

The Relation of Locomotive Maintenance to Fuel Economy*

By Frank McManamy

Fuel economy and locomotive maintenance in practically everything that relates to efficient locomotive performance are synonymous terms.

To fully describe the relation of locomotive maintenance to fuel economy, some features that perhaps should more properly be termed locomotive design must be touched upon because, without studied well-balanced design, maintenance alone cannot effectuate either fuel economy or operating efficiency.

The locomotive of a few years ago was built with little thought for economies. The designer had in mind the creation of a machine that would haul a given load at a stated speed and whose measurements and weights were within certain prescribed limits. Fuel, in most sections of the country, was both plentiful and cheap, and the necessity for economical operation of locomotives was not so acute.

Within recent years the situation has completely changed. The increasing cost and scarcity of fuel have made fuel economy a question of major importance to the designer as well as to the officials in charge of locomotive maintenance. The inventor has also turned his talents in that direction, with the result that the superheater, the brick arch, the combustion chamber firebox and other fuel-saving devices are today parts of the equipment of every modern locomotive. The influence of these devices in effecting real fuel economy is tremendous, and their applications to many existing locomotives will result in a marked reduction in fuel consumption.

Generally speaking, the railroad officials responsible for the maintenance of locomotives have no hand in the selection, purchase or preparation of fuel, but it is their business to get the largest possible measure of performance out of that which is furnished them, and this can only be done by giving constant and careful attention to locomotive maintenance.

Fuel is potential energy. The locomotive is the medium through which this potential energy is transformed into powerful action. The sole object of putting fuel into a locomotive firebox is to develop power at the drawbar, and waste due to failure to maintain this medium through which power is developed and applied is inexcusable. Locomotive maintenance is, therefore, not only *related* to fuel economy, it *is* fuel economy.

Practically every report of a fuel test and every article on fuel economy is prefaced with the statement, "The locomotive must be in good condition." No other single factor is of so much consequence in obtaining the economical use of fuel.

What is meant by a locomotive in good condition?

It means a boiler which generates steam economically but freely, proper steam distribution to the cylinders and efficient mechanism for transmitting the power developed in the cylinders to the only place where the power of the locomotive can be measured—the drawbar at the rear of the tender.

For the purpose of considering locomotive maintenance and its relation to fuel economy the locomotive may be divided into the boiler, valves and cylinders, including steam passages, and the machinery.

The boiler, to promote economy of fuel, must be properly designed, with ample grate and heating surface. It must be clean, the grates level and easily shaken and in good condition, the ash pan and grates must have ample air openings to aid combustion, the fire door should operate easily, and the fire tools should be in good condition. The flues must be clean, the flues and firebox free from leaks, the smoke-box must be air tight, the smoke-stack and nozzle in line, and the draft appliances in good condition and properly adjusted.

Too much stress cannot be laid on the necessity for keeping boilers clean, because, in addition to effecting a material saving in fuel, it increases the efficiency of the locomotive and materially prolongs the life of the flues and firebox sheets.

Frequent and thorough boiler washing is the foundation to proper boiler maintenance, and this has been recognized in all boiler inspection rules, both state and national. Authorities differ somewhat as to the exact loss due to scale on the boiler sheets, but a comparison of tests made indicate pretty conclusively that $\frac{1}{16}$ of an inch of scale will increase the fuel cost approximately 15 per cent and that ¼ of an inch scale will increase the fuel cost approximately 60 per cent.

It is not an exaggeration to say that on an average 40 per cent of the locomotive boilers in service have scale $\frac{1}{16}$ of an inch thick, or, to say it differently, due to poor boiler washing all of them have $\frac{1}{16}$ of an inch scale 40 per cent of the time and many have scale from ⅛ to ¼ of an inch in thickness; in fact, in some districts it is not unusual to find ½ inch of scale on the boiler sheets.

Let us see what this means in actual figures. The railroad fuel bill, along with other things, has been increasing by leaps and bounds. In 1915;the railroad consumed 122,000,000 tons of bituminous coal at an average cost of $1.13 per ton, or a total cost of $157,000,000.

In 1917 they consumed 154,570,000 tons, at an average cost of $2.13 per ton, or a total cost of $329,000,000.

In 1918 it is estimated that they will require 166,000,00 tons, at an average cost of $3.50 per ton, which will be a total of $581,000,000. If we add to this 48,000,000 barrels of fuel oil it will make the total fuel cost over $650,000,000.

We will pay, therefore, during 1918, more than $50,000,000 for fuel on account of the scale in locomotive boilers that many men do not consider of sufficient importance to warrant its removal.

But even a boiler that is clean and in the best condition can do no more than generate steam. Proper steam distribution to and from the cylinders must be had and the steam made to do effective work. If the valves are out of square or blowing, or the valve gear badly worn; if valve chambers or cylinders are badly worn or out of round; if the cylinders packing is worn or broken; if leaking piston-rod packing or leaks about the steam chests or cylinders dissipate the steam that should and could be made to do work, we can expect no improvement in our fuel performance.

Assuming, however, that the boiler is in good condition, that the steam distribution is good and that there is no waste of steam through steam leaks, it remains to deliver this power at the drawbar, and this cannot be efficiently or economically done through the medium of wornout machinery. Rods in bad condition, boxes loose or journals, wedges which require adjusting, and tires badly worn which will cause excessive shipping, are poor mediums through which to transmit energy.

Some of the repairs which will do the most toward reducing fuel consumption and improving locomotive performance, arranged in what is believed to be the relative order of their importance, are: setting the valves properly and maintaining the valve motion, washing the boilers, keeping the flues clean, eliminating steam leaks about cylinders and steam chests, and maintaining the driving boxes and rods.

It should be borne in mind that an 80 per cent boiler with 80 per cent steam distribution and 80 per cent machinery does not make 80 per cent efficiency, but an 80 times 80 times 80, or a 51.2 per cent locomotive.

Each locomotive represents a certain definite investment on which a return must be made. This can be done only by maintaining it in a condition to accomplish maximum results in the way of locomotive performance.

A locomotive can be said to represent 100 per cent of values as an investment as long as it can render 100 per cent service, and no longer. To allow it to deteriorate so that it cannot perform efficient service destroys a portion of that investment just as surely as though it were done by fire, flood or war.

If it were possible to calculate the aggregate loss in operating efficiency for the total number of locomotives that, due to lack of maintenance, are operating at less than their maximum efficiency, the result would be staggering, and when we add to this enormous loss of operating efficiency from 10 to 20 per cent of the railroad fuel bill (which for the past year was $329,000,000, and for the current year is estimated to be $581,000,000 for bituminous coal alone) we begin to realize the price we have been paying for the privilege of operating defective locomotives and delaying traffic thereby. This being true, the question that must inevitably follow is, What is being done by the United States Railroad Administration to remedy the conditions which have been described?

The first step before taking action to bring about an improvement in the condition of locomotives was to make a survey of the field, and, like a good general, this was immediately done by the director general. The records of the United States Locomotive Inspection Bureau were drawn upon for information relative to the general condition of locomotives, and this was supplemented by more detailed information obtained directly from each carrier.

The next step was to speed up locomotive repairs to provide motive power to meet immediate needs, and this was done by increasing the shop hours about 16 per cent for over 200,000 men and by nationalizing locomotive repairs so that a locomotive in need of repairs would be sent to the nearest available repair shop, thus utilizing to the fullest extent the total shop capacity of all railroads. The result of this soon became apparent in the increased number of locomotives turned out of the various shops, which, for the four months ended April 30th, increased 6,849 over the corresponding period for last year. This not only means more locomotives but it means better locomotives, which increases operating efficiency and decreases fuel consumption.

For the future the work that has been started will be continued, and a higher standard of condition of locomotives will be required. A regular schedule for the application of superheaters and other fuel-saving appliances to locomotives not now so equipped, is being prepared and will be adopted subject only to labor and material being available.

Next to wages the fuel bill of American railroads constitutes their largest single item of expense. Locomotive maintenance is the only method of conserving fuel that will of itself show a net profit in addition to the fuel saved. Every item of maintenance that makes for fuel economy also promotes operating efficiency and increases the life of the locomotive. Therefore, the good effects of maintaining locomotives are cumulative, and the bad effects of failing to maintain them increase in the same ratio.

Many fuel tests have been made, and, as previously stated, the first requirement is that the locomotive must be in good condition, thus admitting that the relation of locomotive maintenance to fuel economy is a vital consideration.

We have gained nothing by making fuel tests to determine, for instance, the amount of fuel that can be saved by applying a superheater to a locomotive, with everything in good condition, and then, when the locomotive properly equipped is placed in regular service, to operate it with superheater tubes stopped up, clinkers at the end of the superheater units and honey-comb on the flue sheet, thus making, in effect a condenser out of what should be a superheater. If we add to this ⅛ of an inch of scale on the interior of the boiler, we have lost more in efficiency than we can possibly hope to gain by the application of the superheater. If we apply a brick arch to a locomotive to increase the length of the flame-way in the firebox and to promote more perfect combustion, and then continue the locomotive in service with the flues leaking or stopped up, with the grates in poor condition and with the arch tubes coated with scale, we have lost all of the efficiency which should have been gained by the application of the arch, and in addition we have increased the probability of accident and locomotive failure.

All of the foregoing applies to normal times and average conditions. Today, with the increased demands for fuel by reason of the war and the necessity for furnishing fuel to our allies, and with the increased use of fuel in industries whose output is essential to the successful conduct of the war, the saving of fuel by better locomotive maintenance and the increased operating efficiency which will result therefrom, means more than can be expressed in terms of tons, gallons or dollars. It means *the saving of America, the saving of Democracy, the winning of the war.*

In the conservation of fuel by better locomotive maintenance, as in all other matters relating to transportation, the United States Railroad Administration and the railroadmen of the country who are solidly behind it can rightfully adopt as their motto, "We will deliver the goods."

*A paper read before the International Fuel Association, as reported in *Railway Review*.

Drilling Gas and Oil Wells

Many oil wells are nearly a mile in depth. It costs thousands of dollars to drill a hole even half a mile deep. Oil and gas exist ordinarily in porous formations at varying depths below the surface, and if it were possible to drill wells for oil and gas in the same way that wells are drilled for water, not so many problems would be encountered. But the holes must be drilled through caving formations and through formations containing great quantities of water or gas under high pressure. Heavy pipe ranging in diameter from 4½ to 20 inches must be used to prevent the caving of the formations and to exclude water from the drill hole.

There are two general methods in use in the United States for drilling oil or gas wells—the standard or cable-tool method, in which a percussion drill is used, and the rotary system, in which, as the name implies, the drilling is done by rotating a string of pipe on the end of which is a bit that cuts through the formations in the same manner that a drill bit cuts through a piece of metal.

With the standard method the first drilling is done with a large tool called a "bit," which is raised by powerful machinery and allowed to drop, grinding up the rock. As soon as the hole reaches a depth at which caving begins, a heavy "string" of casing is screwed together and set on the bottom of the hole, and another bit of a smaller size, which will go inside the casing, is lowered into the well, and drilling is resumed in the smaller sized hole. When found necessary the bit is removed and a long string of casing, smaller in diameter than the first casing, is set on the new bottom of the hole and operations continued with the smaller bit. This is done until the oil sands are encountered, the strings of casing resembling a great telescope.—*Yearbook of the Bureau of Mines for 1916.*

Meteorology and Aeronautics*

The Relation of Topographic and Climatic Factors

By William R. Blair

Location and use of base stations.—A knowledge of climatic conditions is of advantage in the selection of locations for aeronautic base stations and in the placing of the fields and buildings. If the region in which a station is located is mountainous or forested or in the vicinity of very high buildings, an exploration of the air to such heights as will include all the peculiarities of circulation introduced by these obstructions to the normal flow of the air is also of decided advantage in this connection. Even when the location of a base station is completely determined by strategic or other considerations aside from climate, the climatic and aerological surveys are of decided value in the plan and use of the station. These meteorological factors have to do with behavior of the engine, with the methods and material used in the construction of the craft, and especially with the ease and frequency of accessibility of the station by aerial routes to aircraft of all kinds.

Fig. 1. Disturbance caused to leeward of a small round tower during a high wind

Disturbances caused by buildings.—From a meteorological point of view places only a few miles apart may vary greatly in their desirability as locations for base stations. Peculiarities of topography, isolated trees, forests, or tall buildings may produce troublesome and often dangerous distrubances in winds that otherwise would be fairly steady. Figure 1 illustrates a disturbance caused in a 22 m. p. s. (50 mi. p. h.) wind by a small round tower. The tower is 5½ meters (18 feet) in diameter at the base, tapers slightly to the eaves, and has a height to the point of the roof of about 6 meters

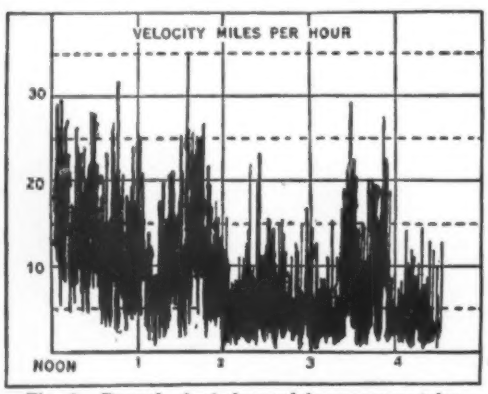


Fig. 2. Record of wind speed by pressure tube anemometer

(20 feet) above the ground level. The ground was kept bare of snow for a width of about 3 meters (10 feet) and a distance of 160 meters (525 feet) to the leeward of the building, at which point the surface took a decided downward slope. As the air current passed the tower two helices were formed. To one standing in the tower the rotation of the air in the helix on his right was counter clockwise; in the helix on his left clockwise, as shown by the suspended snow. The air descending in the middle of the path swept the snow outward and forward to both sides.

Gustiness caused by topography.—Figure 2 illustrates the changes in the horizontal rate of movement of the air as they occur in the average westerly wind near the earth's surface. On the average the acceleration in the horizontal component of the wind speed shown is about 7.5 centimeters per second. Accelerations of three or four times this amount are frequently observed. It would require a positive horizontal acceleration of 17 to 20 times this amount to sustain a bird or well-constructed airplane in soaring flight. In other words, 5 per cent of the force required to sustain the plane is furnished by the average acceleration in the horizontal component of the wind illustrated. An airplane in flight through the wind would experience now this 5 per cent increase and in a few seconds or less time a decrease of equal amount, or a total change of one-tenth the force required to sustain it. Going into the wind the plane would rise in the increasing and fall in the decreasing wind. Going with the wind, the opposite would be true. The effect on the airplane of the variations in air pressure accompanying these changes in the horizontal speed of the air movement is comparatively inconsiderable. Observations of air pressure made near the earth's surface indicate that a pressure variation of one-half of 1 per cent of the total air pressure within a horizontal distance of 30 meters (100 feet) would be extremely large variation, found only in such severe disturbances as thunderstorms or tornadoes. Air density varies directly as the air pressure, and the support given an airplane in a given air mass varies with the air density. It follows that in this extreme case the effect of density variation would hardly be noticeable to the pilot of an airplane compared with the effects of the variations in wind speed illustrated.

Vertical motion in gusts.—These changes in the horizontal component of the air movement must necessarily be accompanied by similar changes in the vertical component. The vertical changes are relatively small in amount, being, in a surface wind of this sort, merely the vertical motion incident to the expansion and contraction of the air as it adapts itself to the contour of the bottom over which it flows. Depending of course on the position of the planes this vertical component of motion is much more effective in proportion to its speed in sustaining an airplane in the air or in forcing it down. In general, however, it is likely that the aviator attaches undue importance to the effects of vertical motion in comparison with the effects of changes in the horizontal speed of air movement.

The extent of disturbances caused by topography.—Depending on the contour of the earth's surface and on

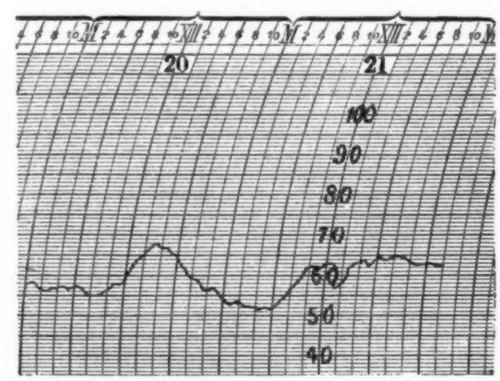


Fig. 5. Surface temperature changes (F) at Drexel aerological station during thunder storm on June 21, 1916

the speed of the wind, gusts of this sort may extend to a height of 40 or 50 meters (130 to 160 feet) or higher. That part of the Blue Ridge Mountains on which Mount Weather is located rises fully 300 meters (1,000 feet) above the valley floors on either side of the ridge. The disturbing effect of this ridge on a wind at or nearly at right angles to the ridge has been observed to extend from 700 to 900 meters (2,250 to 3,000 feet) above the mountain top. The greater heights were observed in the winds of higher speeds. It is probable that disturbances in the lower air brought about mechanically by such obstacles in the path of the wind as trees, buildings, hills, and mountains seldom extend higher than four times the height of obstacles above the general level of the earth's surface in the vicinity of the obstacles. The nature of the disturbance caused depends on the contour of the obstacle and wind speed. Figure 1 illustrates

* Report No. 13, Part II of the National Advisory Committee for Aeronautics on Meteorology and Aeronautics.

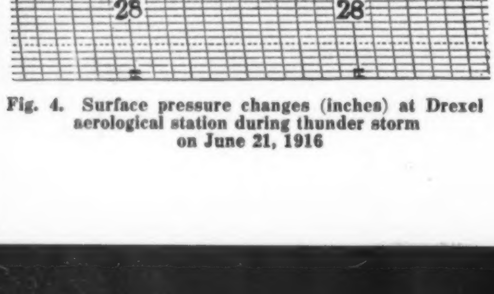


Fig. 4. Surface pressure changes (inches) at Drexel aerological station during thunder storm on June 21, 1916

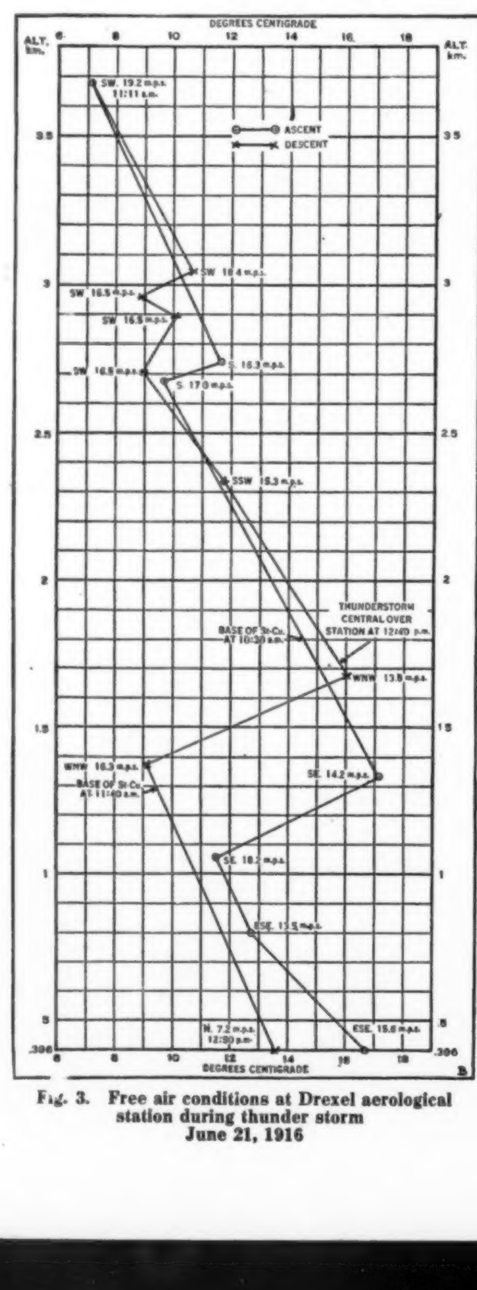


Fig. 3. Free air conditions at Drexel aerological station during thunder storm June 21, 1916

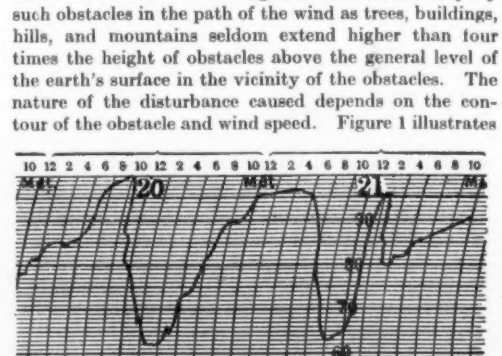


Fig. 6. Surface relative humidity changes (%) at Drexel aerological station during thunder storm on June 21, 1916

one type. Another and a more common type has frequently been observed on a large scale at Mount Weather. In the cases above mentioned, where the disturbance extended to a height of 700 to 900 meters (2,250 to 3,000 feet) above the top of the ridge, the effect of the ridge was to deflect the air upward at all levels above the top of the ridge and for some distance to the leeward. The air in the lower part of this deflected current, soon after passing the top of the ridge, has a downward component of motion which brought it to the valley floor at a distance away from the foot of the mountain, depending on the wind speed. The horizontal component of the motion of this air decreased so that at a distance of sometimes as much as ten times the height of the ridge above the valley floor, the air was descending vertically on the valley floor, part of it returning toward the foot of the mountain and part of it going on out into the valley. That part of the air returning toward the ridge continued up the side of the mountain to near the top, turning here again to join the general current. In one instance a wind of 27 meters per second (60 miles per hour) carried away a kite that was flying at a height of less than 1,000 meters (3,300 feet) above the mountain top. The falling kite was followed by means of a theodolite in order to determine accurately its landing place. After it passed below the level of the mountain top it seemed to descend rapidly into a well-known patch of woods about 3 kilometers (2 miles) from the station; but before reaching the woods it was caught in a fairly strong wind blowing toward the mountain and carried back to within about 2 kilometers (1¼ miles) of the station before it finally settled to the earth's surface.

Disturbances caused by local heating.—The earth's surface varies considerably with regard to its power to absorb radiation and thus becomes more or less heated locally. (S. A. Sup. No. 2201.) Abrupt and frequent variations of this sort in the vicinity of an aviation field need close attention. They intensify considerably the condition of "roughness" or "bumpiness" of the air that prevails at certain times and places, sometimes to the height of 1½ kilometers (about 1 mile) above the earth's surface. Assume that the air overlying a certain area is in stable equilibrium at the time insolation begins on any clear day. A part of the sun's incident on the outer atmosphere reaches the earth's surface but without affecting to any considerable extent the condition of equilibrium of the air through which it passes. A large part of the sun's heat incident on the earth's surface is absorbed and the surface thereby heated. The air in contact with the earth's surface is heated by conduction, decreases in density somewhat and changes places with relatively denser air immediately above it. Thus, the process of transformation from a condition of stable to a condition of neutral or of unstable equilibrium is initiated. It has been shown (S. A. Sup. No. 2201) that the rate at which this transformation proceeds upward depends on the rate of heating of the earth's surface and on the initial stability of the atmosphere immediately above it. Over a plowed field, therefore, which absorbs a certain amount of the sun's heat, the transformation will proceed upward at a given rate. Over a neighboring field of, say, wheat stubble, the surface of which reflects more and absorbs less of the sun's heat than does the surface of the plowed field, the transformation will proceed at a slower rate. At some equigravic surface, below the transformation level over the plowed field, but above this level over the stubble field, the density of the air over the plowed field will be less than that over the stubble field, and, as previously indicated a local convective system the dimensions of which depend on the areas of the fields in question will be set up by way of distributing the heating effects of the two fields. It is clear that small local convective systems of this sort must occur in such a way as to either increase or decrease the general air movement over this part of the earth's surface and that vertical components of air movement will also be added, thus increasing the "roughness" of "bumpiness" of this air to an airplane passing through it.

Climatic factors.—When a larger territory is considered, climatic conditions are found to vary greatly from place to place. These climatic conditions determine in a general way what aeronautical work can best be done in any part of the country and the desirability of any particular place as a location for an aeronautic field and base station. Data are now in the Weather Bureau files sufficient for the purpose of comparing different places throughout the country with respect to their accessibility by aerial routes for different types of aircraft, *i. e.*, the sort of aerial harbor, ease of entrance and exit, and othes things considered which aircraft would find at these places. These data for any place and the inferences based on them can be made available on short notice. The climatic factors that most need consideration in this connection are outlined as follows:

1. Wind:
   (*a*) Direction.
   (*b*) Speed.
2. Temperature:
   (*a*) Normal.
   (*b*) Maximum and minimum.
3. Precipitation:
   (*a*) Normal.
   (*b*) Excessive.
4. Fog.
5. Relative humidity.
6. Cloudiness.
7. Air pressure.
8. Thunderstorms, tornadoes, and hurricanes.

Use of climatic data.—Some discussion of the separate topics in the above outline may serve to indicate the reason for their consideration, the form in which the data can be found, and the way in which they can best be used. In general data should be considered by months and the suitability of any location as an aerial harbor determined in this way. A place may be an excellent one for aeronautic operations during certain months of the year but less suitable during other months. This distribution of suitability throughout the year is of prime importance and the study of the data by months enables it to be determined with sufficient closeness.

Wind speed and direction.—The prevailing direction of the wind and the mean speed of the wind from each direction at a place selected for the establishment of an aeronautic station should largely determine the layout of the grounds and the orientation of the buildings. All aircraft, but specially those of the lighter-than-air types, can leave or enter a hangar with greater ease and with less likelihood of damage to the craft when going into the wind than when the wind or a considerable component of it blows across the entrance of the hangar. For heavier-than-air machines it is specially important that the field be so laid out as to furnish plenty of clear way for launching and landing parallel to the prevailing wind directions. Prevailing wind direction by months and also by hours for the 24-hour period, together with the mean speed of the wind from each direction, can be furnished by the Weather Bureau for a large number of places well distributed throughout the country.

Gales.—Winds of high speed render the launching and landing of aircraft difficult. The limit of wind speed above which it is inadvisable to attempt launching aircraft varies with the type of machine. Pertinent information on this point is found in the Weather Bureau records of the number of days with gales at its different stations.

Wind direction and gustiness.—It is much more difficult to handle aircraft in a gusty than in a smoothly flowing wind. Gustiness is usually measured and expressed as the rate of change from second to second in the horizontal speed of the wind. Change of speed in the horizontal direction is, as a rule, accompanied by more or less change of speed in a vertical direction, and may be taken as a fair indication of the turbulence of the air current from the aviator's point of view. As a rule west winds are gustier and therefore "bumpier" than east winds. This difference in the nature of the winds is not based on the wind direction at all but follows largely from the relative densities of the air flowing in these currents. The air in a west winds, because it is moving in the same direction as the surface of the rotating earth, exerts a very slightly greater downward pressure, depending on its rate of movement, than does air of equal density moving from the east. If two such currents met, the tendency would be for the west wind to keep to the earth's surface, forcing the east wind to a higher level. It is also true that the air of westerly winds in this country is usually drier and colder and therefore denser than the air of easterly winds. As a result of this difference in density the westerly wind lies close to the bottom over which it is flowing. If this bottom be a topographically rough part of the earth's surface much local expansion and contraction, or gustiness, will occur in the westerly air current as it adapts itself to the topography. Such gustiness would not occur in a wind that did not lie so close to the bottom over which it is flowing. A sea breeze, for example, regardless of its direction, is likely to be much freer from gusts and consequently smoother than the land breeze over the same point. The air of the sea breeze flows over a comparatively smooth, uniform surface, while that of the land breeze flows over a comparatively rough solid surface the nature of which also vary greatly from place to place.

Air temperature and "roughness."—The normal air temperature at a place used as aeronautic base, also the minimum temperatures likely to be experienced, is of interest in connection with the operation of the engine, and the comfort of the pilot and others handling the machinery. The maxima of temperature likely to be experienced are of interest from this and also from an entirely different point of view. It is likely that all days with temperatures 32° C. (90° F.) or above will be days on which the surface air is quite rough because of considerable convectional action. The depth of the rough or bumpy air increases during insolation until well into the afternoon. Depending on the length of the diurnal period of insolation the maximum depth of this condition on a clear day is likely to be 1 to 1½ kilometers (¾ to 1¼ miles). It is turbulence of this type that is specially likely to be increased by sharp variations in the nature of the earth's surface with respect to its ability to absorb or reflect solar radiation.

Precipitation.—Precipitation, whatever its form, is not necessarily a hindrance to flying, but the added weight on the aircraft, as well as the poor visibility, are great handicaps, and excessive precipitation or any form may render flight impossible. The added weight of rain or snow on the craft may be considerable. A snow cover, especially when the snow has freshly fallen, so changes the appearance of the earth's surface and covers up roads and other lines that the aviator has difficulty in keeping his course.

Fog.—Fog is a serious hindrance to aerial navigation. It is practically impossible to keep a course in a given horizontal plane or indeed to know in what plane the craft lies.

Humidity.—Whether the relative humidity is high or low is not an important consideration unless the air is so extremely dry that special care is required in seasoning the wood used in the propellers and other parts of the craft, as well as in the construction of these parts and in the glues and varnishes used. The amount of moisture in the air affects the operation of the gasoline engine, but this is a point of secondary consideration.

Cloudiness.—While in military operations the aeronaut may use a cloud cover to advantage, the average pilot in times of peace prefers a clear sky when he flies. The presence in the sky of certain types of clouds, viz, clouds which form because there is an upward component in the movement of the air below them, indicates a more or less turbulent condition of the air from the earth's surface up to the cloud base as well as within the cloud itself. Such clouds may be scattered cumuli or in the form of a fairly solid cloud. In every case the bases of the separate clouds or of the cover appear sharply defined and uniform in height. The disturbed condition of the air within the cloud may well be thought of separately from that below the cloud base since in the cloud other causes of turbulence are in operation owing to the presence of the cloud particles. These causes produce turbulence within clouds of other types as well as in those which form in air having a vertical component in its motion. While the pilot may expect "rough" air within any cloud, the presence of the convectional cloud forms, specially of scattered cumulus clouds, leads him to expect "rough" air below the cloud level as well. (S. A. Sup. No. 2201.)

Frost and ice formations on aircraft.—Aircraft remaining for some time in a fog or cloud layer, when the latter is at low temperatures, are likely to collect a considerable weight of moisture in one form or another. This is specially true of the lighter-than-air craft. Cloud and fog particles maintain themselves in liquid form at temperatures far below freezing. If this be because of the surface tension of the particle, any influence that breaks down this tension would permit the freezing in one form or another of the water of the particle. Assuming that aircraft within a fog or cloud layer at temperatures well below freezing is electrically charged, surface tension of fog or cloud particles approaching it will be broken down and, depending on the size of the particle and the temperature, freeze on the cold surface of the aircraft in crystalline or amorphous form. Similar conditions, but with higher temperatures, may result in the collection of liquid moisture on the surface of the craft.

The air pressure.—The air pressure, or the height above sea level of an aeronautic base station, affects chiefly the operation of the gasoline engines.

Traveling disturbances considered.—While this chapter concerns itself chiefly with the sort of aerial harbor that can be had in any particular location and not with the laying or pursuit of a course between two points, it is thought best not to divide the consideration of the next topic—thunderstorms, tornadoes, and hurricanes—although it has to do with courses pursued between two stations as well as with the accessibility of either station by aerial routes.

Thunderstorms, hurricanes, and tornadoes.—These are disturbances in the lower atmosphere of relatively small area and may often be seen approaching in good time for the pilot, if he be in the air, either to fly around them or to land until the disturbance has passed. The aeronaut would benefit greatly by some knowledge of the nature and extent of these disturbances.

Frequency of thunderstorms, etc.—The frequency of occurrence of disturbances of these sorts in a given region

may be taken as an indication of the turbulence of the air in that region. Consequently data on thunderstorm frequency, would be of value in the consideration of a location for a base station. Such data are in the Weather Bureau records and are readily available.

A thunderstorm described.—During a kite flight on June 21, 1916, at the Drexel Aerological Station, 32 kilometers (20 miles) west of Omaha, there occurred a typical thunderstorm. Figure 3 shows the temperature gradient observed in both ascent and descent. Wind directions and speeds, cloud base heights, and other notes are made on the curves showing the temperature-altitude relation. Figures 4, 5, and 6 are the barogram, thermogram, and hydrogram, respectively, recorded during the passing of the storm. The observer of surface meteorological conditions makes the following notes:

Thunder to the west was heard at 12.15 p. m. A threatening dark, purple-tinted cloud was observed to the north and west of the station at 12.30 p. m. Lightning flashes were seen in this cloud about the same time. The wind changed from ESE to WNW at 12.40 p. m. The loudest thunder was heard at 12.46 p. m. Light rain began at 12.47 p. m. and heavy rain a minute later. Last thunder was heard to the northeast at 1.05 p. m. Rain ended at 1.54 p. m.

The observer at the kite station makes the additional observations:

Reeling in at high speed the kites passed directly over the reel house when the wind changed abruptly from ESE. to WNW., *i. e.* the wind did not swing in a semicircle but changed by directly reversing its direction. There was evidence of an upward component in the air's motion when the wind change at the surface took place. The surface ESE. wind, which gradually turned to S. and SW. as the altitude increased, gained considerably in speed as the storm approached.

Explanation of the records.—The rise in pressure shown by the barogram and the fall in temperature shown by the thermogram are simultaneous and occur at the time of the wind change above described, or, in the case of this storm, seven or eight minutes before the first precipitation. The rise in humidity begins when the rain begins. The height of the cloud base indicated in Figure 3 is about 1 kilometer (0.6 mile) above the earth's surface, that of the upper surface of the cloud 1.5 to 2 kilometers (0.9 to 1.2 miles) higher. At the time of the sudden change in pressure and temperature it appears that the relatively cool and therefore dense WNW, wind forced the warmer ESE wind up from the earth's surface. Assuming that the surface air of this latter wind reached the cloud base level by the time precipitation began, it would have an upward component of 2 m. p. s. (4.5 mi. p. h.). The horizontal component of the speed of this current of air is indicated in Figure 3 is about eight times the supposed vertical component. These are ideal conditions for soaring flight, but a too near approach to the boundary planes between the different currents in action here would be dangerous because of the great differences in wind speed and direction that obtain.

Warning of thunderstorm's approach.—The aviator has in the case of the storm just described a warning of from 20 to 25 minutes. It would be unwise to get into the region of the abrupt wind change. In this time he should either effect a landing or change his course so as to go around the storm either to the right or left of it or above it. The direction and rate of motion of storms of this type are fairly well indicated by the winds in front of them and by the appearance of the cloud.

Thunderstorm frequency.—While data on thunderstorm frequency indicate that these storms occur more frequently in certain regions of the country than in others, it may be well to consider varaitions in this frequency at a particular location. It has been shown above that thunderstorms occur when a denser, usually colder, air mass flows under and forces up a less dense, usually warmer, air mass. In other words thunderstorms are most likely to occur at the boundary between a warm and a relatively cool air mass or at the breaking up of a hot spell. In a following chapter, in which the weather map is discussed, it will be shown that the region of greatest thunderstorm frequency for a given location is to the south of a low-pressure area. Thunderstorms are occasionally found to occur to the south of high-pressure areas and less frequently in regions aside from those two, where the topography or nature of the surface in combination with local conditions give rise to them, *e. g.*, where the earth's surface is much broken by hills or mountains. On land, thunderstorms of the type above described have a diurnal maximum of frequency. This maximum occurs just after the hottest part of the day, or following 3 or 4 p. m. Thunderstorms are decidedly more frquent in the summer than in the winter months.

Turbulent conditions indicated by thunderstorms.—Thunderstorms may be occurring over a considerable area, though at the same time no one storm is of very great area, and may possibly be avoided by a pilot who has got well into the air. It is the turbulence of the air, indicated by the occurrence of thunderstorms in the region, that is of especial interest when the accessibility of a given field by aerial routes is being considered.

Cyclonic thunderstorms and tornadoes.—There is another type of thunderstorm which usually occurs within a heavily clouded or rain area. In this type it is thought that the origin of the disturbance is in the cloud layer. There is a sharp drop in the surface pressure while this storm passes and an almost immediate return to pre-storm conditions. This type of storm is not nearly so common and does not seem to have been so fully investigated as the type above described. The wind action seems to be cyclonic, and the two kinds of storms may well be designated "line" and "cyclonic." It is quite conceivable that a thunderstorm of the cyclonic type could also originate as a result of excessive local heating, the area heated being relatively small when the excess of heat is considered. This origin is all the more probable when the heated area is near the boundaries of passing air currents. Extremely severe cyclonic thunderstorms may develop very high wind velocities and do great damage specially on the right half of the storm's path. When they have so developed, these storms are called tornadoes.

Tropical cyclones or hurricanes.—These are, as a rule, storms of larger area than either thunderstorms or tornadoes. They seem to have a similar origin, *i. e.*, they occur on the boundary between air masses of different densities and moving in opposite, or nearly opposite, directions. These storms are of a more permanent type than either thunderstorms ot tornadoes. They can, therefore, be foretold for a greater length of time (sometimes for several days) ahead of their occurrence than can the shorter lived thunderstorms and tornadoes.

Direction of travel of disturbed condition.—Thunderstorms of the line type seem to travel approximately at right angles to the line between the two air masses of different density in which they originate and into the warmer air mass. Those of the cyclone type including tornadeos appear to travel with the general drift of the air in the upper part of the stratum in which they occur. Hurricanes originate in the trade wind belt in the summer half of the year and extend up into the antitrades. The antitrades seem largely to control the direction and rate of travel of these storms. Where the direction and speed of travel of storms is largely determined by the direction and speed of an upper wind current, systematic observations of this current by means of kites or free balloons aid greatly in predicting future positions of the storm at given times.

The Chemistry of Silicates*

With Reference to Their Use in Dental Operations

By C. C. Voght, Ph.D., Mellon Institute of Industrial Research

The object of this paper is to bring before you the chemistry of the silicates, pointing out some practical illustrations which may be derived from these theoretical considerations. It is evident that the more complete the knowledge of the dentist concerning the physical and chemical properties of the materials with which he works the more nearly will he approach perfection in the practical application of them. A silicate filling material consists of a powder and a liquid which are to be mixed according to more or less definite instructions.

POWDER

Constituents.—The usual constituents of the powder of a silicate are silicon dioxide, calcium oxide, aluminium oxide, sodium and potassium oxides and flurine. Oxides of other metals such as zinc, magnesium, beryllium, strontium, etc., are sometimes used. Non-metallic oxides or acid anhydrides, as, for example, the oxides of phosphorus, boron and titanium may also be present. The development of a material of the silicate type was due to the demand for a translucent filling material which could be inserted while plastic as is the case with a zinc cement. Such a material would equal porcelain in appearance, and, since it could be inserted in the plastic state, the technique employed in its use would be far more simple than that required for the porcelain inlay. A product possessing these desirable properties would be a welcome addition to those in use before the silicate was discovered.

Examined under the microscope, a hardened pellet of oxyphosphate of zinc shows that there are masses of translucent zinc phosphate which hold together the opaque grains of the zinc oxide. Had it happened that zinc oxide itself was translucent there would have been no need for the silicate.

The problem was, therefore, to find a substance which, being translucent itself, would act as the basis of the powder. A study of the metallic oxides—and because of their basic properties the oxides are the only compounds available for the purpose—showed that calcium and aluminium are the ones best fitted for use. But calcium oxide is both opaque and too caustic so that it must be modified before it can serve as a basis for the powder. Precipitated aluminium oxide, *i. e.*, alumium oxide plus water, which has been dried at a low temperature makes a very adhesive mass but it also is too opaque and lacks density. If the aluminium oxide is heated strongly in order to increase its density it becomes so inactive chemically that the powder and the liquid will not react, so it too must be modified. Therefore, one must subject these oxides to a treatment which will not destroy their ability to react with the liquid but will produce a profound change in some of their properties. A study of the translucent porcelain tooth reveals that it is composed of aluminium oxide, sodium and potassium oxides and silicon dioxide, so this gave a hint of how to combine these materials and the combination of calcium oxide with these components was logically the next step in the process. Now the problem resolves itself into how to put all these materials into a translucent melt which would react with the liquid.

Since calcium oxide and aluminium oxide are both basic oxides which react with the acid quite readily it is evident that the melt must be one in which the proportion of basic oxide is greater than that of silica, and acidic oxide. After a melt of this kind has been worked out it is found necessary to add some additional components such as fluorides in order to aid in fusing at a low enough temperature to keep the aliminum oxide in such a condition that it is chemically active while the melt remains translucent.

The method of production of a silicate powder is, prepare a strongly basic silicate which is in itself translucent. Because of its basic properties this material will readily react with the liquid and being translucent itself it will form a translucent mass with the translucent binder.

The various components are sifted and mixed, then fused at a temperature of 2,000 degrees to 2,500 degrees F., to a homogeneous liquid. The resulting melt is poured out from the crucible, the fruit is ground in ball mills, sifted through a fine sieve and is then ready for use.

Composition.—The actual chemical composition of this fused material is not known—it being an extremely difficult problem to determine the definite chemical individuals in an amorphous solid. The constitution of such long known substances as porcelain and glass is not known exactly despite years of investigation and they are less complex than melt for a silicate powder. There are to be found in a silicate powder, probably, calcium alumium silicate, sodium and potassium aluminium silicates (feldspars), along with fluo silicates and in some cases borates, phosphates and titanates. However, this much is certain, that the melt is essentially a strongly basic silicate, *i. e.*, one in which the percentage of metallic oxides or their equivalents is very high. This must be true in order that the powder and liquid may react freely.

LIQUID

Constituents.—The liquid is made up of phosphoric acid diluted with water to which one or more metallic oxides have been added. These oxides are added in such quantities that they dissolve completely in the acid solution. The oxides added are those of calcium, strontium, beryllium, zinc or aluminium.

The purpose of adding these metallic oxides is twofold: (1) to reduce the acidity of the liquid by the interaction of the metallic oxide or oxides and phosphoric acid forming a salt and water, thus using up a part of the free acid; (2) to regulate the rate of setting of the mixed silicate. The presence of the dissolved oxides which, when dissolved, form the corresponding acid phosphates, decreases the rate of setting.

Composition.—The liquid consists of a concentrated solution of metallic acid phosphates along with some free phosphoric acid.

Reactions during Mixing.—When the powder is added to the liquid the following reactions probably occur: (1) The metallic oxides or their equivalents in the powder react with the free acid in the liquid to form water, and the acid phosphates of calcium and alumium. (2) the acid phosphates formed in the first reaction and the acid phosphates already present in the liquid react with more of the basic powder producing the normal phosphates and water. It is these normal phosphates which possess the adhesive and cementing qualities, hence it is evident that the greater the quantities of these salts which are produced during the mix the better the silicate, consequently since mixing facilitates the interaction of powder and liquid the more thorough the mixing the better the filling made from this class of filling materials. Evidently one

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had to do with the reaction between a solid and a solution. This class of reaction is necessarily slow since the rate of any chemical reaction depends upon the number of molecules of the reacting substances which can come into intimate contact. Obviously only the surface of the solid can reset with a solution. The reaction can be made more complete by stirring, just as salt will dissolve more thoroughly when stirred because new molecules of water come into intimate contact with the solid salt. These facts make it evident that thorough mixing is very advantageous. A second advantage of thorough mixing is that the acidity of the liquid is reduced to a minimum by the complete reaction between powder and liquid.

That there can be little danger of mixing a silicate too much can be proven by the following experiment: a powder made by crushing and grinding a hardened pellet will react with the silicate liquid producing a coherent mass showing that not all the grains of powder have been completely acted upon in the first mix. A third advantage of thorough mixing is the regulation of the evolution of heat during the chemical reaction.

A definite quantity of heat is produced by the interaction of a definite quantity of powder and liquid. This is due to the heat liberated by the neutralization of the phosphoric acid by the metallic oxides in the powder. If the mixing is carried out too rapidly, this heat is liberated so rapidly that it becomes evident to the senses. On the contrary, if the mixing is slow and thorough the heat is evolved so slowly that it is readily taken up by the air. No one would think of adding a ton of coal to an ordinary furnace at one time—he adds it by the shovelful and thus distributes the heat.

The *effect of the change of concentration* of the liquid is to *modify* materially the rate of setting of a silicate. Experiments demonstrate this so fully that I am going to illustrate this point by three mixes; (1) Normal mix; (2) Liquid plus phosphoric acid; (3) Liquid plus water. (1) Represents a proper mix; (2) sets too slowly. This is the case when the stopper is left out of the liquid bottle. Some of the water evaporates and this concentrates the solution. (3) Sets too rapidly.

This is what happens when: (1) The stopper is left out of the powder bottle and moisture from the air is absorbed by the powder.

(2) The slab takes up some moisture from the air on a warm, moist day or when the slab has been imperfectly dried. The cautions to be observed are too obvious to require enumeration.

HARDENING

The hardening of silicates takes place in two stages the initial action is complete in 5 to 20 minutes, while the secondary hardening extends over a very considerable period of time, months and perhaps even years. However, the maximum change of physical properties takes place in 24 hours, the change in physical properties after that being very slight. A curve expressing the change in physical properties during the time of setting shows a very decided increase during the first 24 hours while after that time the increase is very slow.

Initial hardening.—The initial hardening is probably due to the combination of water with the metallic phosphates formed during the mixing to form crystalline salts. You are, no doubt, familiar with the fact that copper sulfate combines with water to form the well known blue vitriol crystals and the two reactions are analogous. The acid phosphates formed during the first part of the mix are extremely soluble in phosphoric acid and as they are converted into the very insoluble normal phosphates they combine with water and crystallize out in so dense a mass of minute, interlocked crystals that the individual crystals cannot be detected even by a high-power microscope. The formation of these untramicroscopic crystals is favored by their crystallization from strongly concentrated solutions.

The excess of powder over that required for the formation of these crystalline salts is held by the crystals just as sand and gravel are held by the cement particles in concrete.

The experiments showing the very marked effect of small quantities of water upon the rate of setting make it evident that any theory of hardening which does not explain the part taken by water in the reaction cannot be seriously considered. The water plays a most important role in the hardening and its presence must be accounted for.

The initial hardening is analogous to the setting of an oxyphosphate of zinc cement and in this respect the chemistry of the two is quite similar. It is in its secondary hardening that the silicate radically differs from the oxyphosphate.

Secondary hardening,—The secondary hardening seems to be due to the same general causes as the setting of Portland cement. It is most probably due to the following causes:

(1) The combination of water of crystallization with calcium and aluminium silicates to form crystalline salts. (2) The dessication of colloids. This drying out of colloids is well illustrated by the drying of glue. Both these reactions are slow and require long periods of time for their completion.

There are three practical points to be learned from this theory of setting:

(1) The fact that silicates lose their translucency and show signs of cracking on the surface is due to the fact that the crystalline salts lose their water of crystallization on exposure to the air. Here is a blue vitriol crystal which has been exposed to the air. It is evident that it has undergone change on the surface for it has lost its color and is powdery. Compare it with this crystal which has been exposed to the air. These two samples of silicate, one protected from the air by water and the other not so protected, are the same phenomenon. Any form of protection from dry air such as a varnish or keeping in an atmosphere of moist air will prevent the evaporation of water from the surface of the silicate. A silicate—when hardened—is hydraulic and must remain in the presence of water in order to be at its best.

(2) Because of the time required or the secondary hardening any silicate filling should be left 24 hours before finishing. While a filling finished at the same sitting as its insertion may and often does prove satisfactory it *cannot* be as perfect as one finished at a subsequent sitting. No dentist would think of disturbing a concrete sidewalk in front of his house until it had hardened, so why should he interfere with the proper crystallization of a filling in a patient's tooth?

While the silicate is in the plastic state it is *not* hydraulic. This is due to the fact that the formation of the insoluble hydrated phosphates from the soluble acid phosphates requires some time for its completion. Hence in order to avoid the solvent action of moisture at this stage some precautions must be observed:

(1) The tooth should be isolated by the rubber-dam. (2) The cavity should be dry.

These simple methods will prevent any solution of the soluble salts before they have had the time necessary to convert them into insoluble ones.

(3) Inasmuch as the silicate undergoes a secondary hardening accompanied by a marked change in physical properties, in order to obtain the best possible results the filling should be coated with a varnish or other waterproof coating which will prevent moisture from interfering with its proper crystallization.

One would not use the garden-hose on a cement walk until at least 24 hours after it had been placed so why should he permit water to come in contact with a silicate filling, the secondary hardening of which is analogous to that of Portland cement, until that filling had been allowed the same length of time for the final step in its hardening?

CAVITY PREPARATION

This subject has been so fully and ably discussed by Doctor Davis and Doctor Voelker in papers already published that I shall merely refer to this topic in the briefest way:

Square margins with good retention are indicated in order to give the best opportunities for adhesion and permanence.

If the dentist who uses silicates is familiar with the physical and chemical properties of this class of filling materials the technique is extremely simple, just as the process of addition is simple provided one has learned the meaning of the figures employed in arithmetic so the proper uses of a silicate attended by satisfactory results is easy so soon as the dentist understands the properties of the material itself:

To sum up briefly:

(1)—The presence of foreign substances of any kind whatsoever interferes with the reaction between the powder and the liquid and with the proper crystallization of the silicate. Therefore, use extreme care to prevent any contamination either of the material itself or of the slab or the instruments used during the insertion of the filling.

(2) The reaction between the powder and the liquid is slow. Therefore, aid this reaction by thorough mixing.

(3) In its plastic state the silicate is *not* hydraulic. Therefore protect it from moisture in every possible way until it has hardened.

(4) The secondary hardening requires at least 24 hours. Therefore coat the filling with a waterproof varnish to keep it away from moisture and do not finish it until the 24 hours will have elapsed.

(5) The silicate is hydraulic after it has hardened fully. Therefore test pellets should be kept under water duplicating the moist environments of the filling in the mouth.

The whole law and the prophets is summed up in the single statement;

Understand the physical and chemical properties of the silicates—and then use common sense.

Grapevine Parasites and Their Treatment

In France the question of grapevine treatment is of great importance, owing to the considerable losses which occur from the action of various parasites. Among these, the principal ones are the *cochylis* and the *endemis*, and these parasites need to be destroyed by a suitable treatment. The larva of the *cochylis*, when at its full stage of development, is about half an inch in length. During the early period it is of a gray color, but afterward becomes pink or of a reddish or violet color. The head is of a brownish black and the first segment of the thorax has a wide band of a dark hue. As to the larva of the *endemis*, it is of smaller size, or about 0.4 inch length, and the body is at first a greenish gray at the spring and summer hatching, but it becomes a purple gray in autumn. The head is of a brownish red but is of lighter color than for the *cochylis*. The band which is seen on the first segment of the thorax is darker than the head, but is much narrower than in the former case. In both cases the chrysalis which is formed during the winter produces the moths in the month of May, the moths of the cochylis are nocturnal, while those of the endemis fly only at twilight or daybreak. The female moths lay their eggs on the flower of the grapevine, from which the larvae are hatched after seven or eight days, and they spin out a silky web construction under cover of which they attack the vine. The larva forms a chrysalis after about twenty days, and it is only at the end of June or in July that the new moths appear, and the females then lay their eggs. New larvae come from these, and they attack the seeds of the grape in July or early in August. The cochylis has only two generations each year, while the endemis has three. The third generation of endemis larvae attack the seeds of the grape while these are becoming matured. Different methods are employed to combat both these parasites during the period of vegetation. For the moths there are used baited traps or sticky surfaces, while the larvae are treated with various solutions. It is difficult to secure good results upon the moths, and besides such treatment is expensive and requires much hand labor. Treatment of the larvae in various ways is preferable, on the whole. Passing over the operation of picking off the larvae—which although very effective in theory is hard to carry out in practice and also requires much labor—reference may be made to the different solutions which are applied on the vines. Arsenate of lead is found to be the most effective, but as this substance is very poisonous it is not to be recommended on that account, and in France there are even rules against the use of arsenical substances in agriculture, at least in many cases, so that as soon as the flowers appear, it is indispensable to use the treatment by nicotine solution, while the arsenical baths can sometimes be employed before this period. The powdered substances for the arsenical baths are now found in commerce and are simply dissolved in the proper amount of water, and are applied by spraying devices, either alone or mixed with copper salts or sulpho-calic baths. After the flowering, that is, in order to combat the second generation of the cochylis and the second and third generation of endemis, it is recommended to employ nicotine or barium salts. Nicotine is preferable, provided it can be procured, this being difficult in France just at the present time.

The tobacco factories produce two kinds of extract, one being the ordinary kind, while the second is of extra strength and contains a large amount of nicotine. In general, the ordinary extracts show 110 degrees on the densimeter and may contain from 12 to 16 parts of nicotine per 1,000 of liquid. Such liquids should not be employed, for they are subject to fermentations which diminish their effect to a great degree, and besides a large amount of the liquid must be handled to perform a given work. The concentrated extract usually contains sulphate of nicotine, which is regulated at 100 parts of nicotine per 1,000. Some of the factories produce oxalate of nicotine instead of sulphate. These liquids have the advantage of not containing any matter which will ferment, and besides they have a standard aquantity of nicotine. To employ the concentrated extract upon the vines, they are diluted with water to make up a 1 to 1.7 per cent solution. When used at 1.3 to 1.5 per cent, such baths have a great destructive power. Messrs. Capus and Feytand, who have made extensive researches upon the cochylis and endemis, recommended the use of the above baths at the time when the moths first appear, for the solution has two effects, one to drive away the moths and the second to kill the larvae by internal absorption. The concentrated nicotine solution can also be added to the usual sulphate of copper baths, for instance 1.3 to 1.5 or even 1.7 parts for 100 parts of copper solution. As to the use of barium chloride, it is usually employed in a 1 or 2 per cent water solution, according to the time of the year. But it cannot be mixed with copper baths, as the sulphate of copper will precipitate the barium.

The Alimentary and Economic Value of the Jerusalem Artichoke

Among those kitchen vegetables whose virtues have been largely overlooked in this country the Jerusalem Artichoke (helianthus-tuberosus), is one of the most important. The value of this plant, which belongs to the great family of the Synanthereae, not only for human food and as a forage plant, but industrially and economically is so great that it was recently made the subject of a special report before the French Academy of Agriculture. We quote from *La Nature* the following summary of its merits:

Official statistics show that its yield is much heavier than that of the potato. It should be noted moreover, that potatoes are subject to parasitic diseases, which often greatly reduce their yield, while Jerusalem Artichokes show great resistance to these pests as well as to extremes of heat and of cold; therefore the crop is always certain. Moreover, it is easy to take care of the tubercles, as on account of their resistance to frost, the roots may be left in the earth until needed.

Since this plant takes from the air the carbon it needs as well as a portion of the nitrogen, hydrogen and oxygen which constitute its substance, it takes from the soil only a small amount of nitrogen, and a portion of its mineral elements, the remaining portion being derived from rain water. Even more than sixty years ago Kade proved by his experiments that this plant can be grown on the same ground for at least thirty years without a decrease in yield, thus demonstrating that it does not exhaust the earth as most plants do. It grows in all sorts of soil and requires as little cultivation as it does fertilizer. It gives especially good results in sandy earth of gneiss or granite origin. The only ground unsuitable for it is that which is too damp or which has an impermeable sub-soil. In Champagne it grows in chalky earth; in Britany on schistous soil; in the Bordellaise on the earth of the lands and dunes; while in Alsace, Sologne, Touraine, in the Bourbonnaise, etc., it is found growing in argilo-silicious earth. In 1914, 112,450 hectars were devoted to this plant in France; in 1915 this was reduced to 99,977 hectars, and this area has been further reduced in consequence of the lack of farm hands.

The Jerusalem Artichoke has an even better title than the potato to be considered a "war plant," that is, a rustic plant which is not only very productive and whose expense of cultivation is slight, but one which can be utilized in various ways. It not only furnishes a considerable quantity of food fit for human consumption, but a large amount of animal fodder; moreover, it can be used for making industrial alcohol. Its tubercles contain no less than 14.7 per cent of non-crystallizable sugar as well as 3.12 per cent of nitrogenous substances, and while it is of watery consistency it is not much more so than the potato; it contains twice as much dry matter as the beet root and two and one-half times as much as the turnip. The alimentary value of the tubercles runs as high as 23.96 per cent. It is richer than the potato in fats, in sugar and in phosphates. The tubercles may be steamed until soft and eaten with a white sauce, but they are better mashed and fried in cakes like potato cakes. They may also be used in stews. They possess a property particularly valuable at the present time, that of combining well with flour so that they may be used in making bread. For this purpose they are first boiled and then incorporated with wheat, rye, barley or a mixture of wheat and rye flour, using the artichoke pulp and the flour in equal portions. About a quarter more yeast is required than in ordinary bread making. This artichoke bread keeps fresh a long time without undergoing alteration.

The tubercles contain a large proportion of substances which may be used for distilling alcohol, such as glucose, inuline and gum, comprising about 18.88 per cent of their substance when fresh. Fermentation is easily induced since the plant contains as high as 3.12 per cent (1.86 on the average), of albumenoid substances, *i. e.*, matters capable of being fermented. From 100 kilograms of tubers 18.88 kilograms of glucose are obtained, and 100 kilos of glucose furnish 51.12 kilos of absolute alcohol; consequently 100 kilograms of tubers yield 9.65 kilos, or 12 liters of anhydrous alcohol. Dividing these figures in half to obtain a so-called "practical figure," we may count on six liters of 90 per cent alcohol, or 12 liters of 50 per cent alcohol per 100 kilograms of fresh tubers, *i. e.*, about 120 liters per ton. By proper methods of cultivation 20,000 kilograms of tubers per hectar can be obtained, *i. e.*, 30 hectoliters of 50 per cent alcohol per hectar.

Moreover, each 100 kilograms of tubers yields 80 kilograms of pulp, which, when fermented with straw or chaff, the siliques of colza, hay, lucerne, etc., makes excellent fodder for domestic animals, quite like the tubercle itself. In practice 250 kilograms of the tubercles can be substituted for 100 kilograms of hay in the feed of horses, cattle and sheep. The Germans use them so extensively for this purpose that they are commonly called horse potatoes. When cooked and mashed they also provide an excellent food for poultry, especially turkeys. They are given mixed with milk and cornmeal or barley flour. They are very fattening as a food for animals and are cheaper than beet root rations, thus reducing the cost of meat, milk and horse or cattle labor. The stalks, which can be used either green or dried, are almost as useful as the tubercles. One hundred kilograms of the green stalks have a fodder value equal to 31.25 kilograms of dried hay. They may also be fed in the dried form to horses and sheep. They form an excellent form of litter, since the pith of which they are chiefly composed absorbs a large quantity of liquid droppings. They likewise have considerable combustible value. It is estimated that the dried stalks from one hectar (8,000 to 10,000 kilograms) are equivalent to 19 cubic meters of wood.[1]

The helianthus-tuberosus may be grown in all climates and upon all soils except swampy soils. Of all plants grown for the sake of their roots or tubercles this is the one that succeeds best on soils of poor quality, and which gives the largest yield while demanding the smallest quantity of fertilizer. Naturally, however, when more heavily fertilized, the yield is far larger. It must not be forgotten in this respect that this plant has a valuable faculty of extracting saline substances and binary and tertiary nitrogenous compounds, such as ammonia and nitrogen from the atmosphere, as well as earthy and alkaline carbonates and phosphates. The cultivation of this plant actually improves the ground it is grown on instead of exhausting it, since the organic matter of the harvest exceeds that of the fertilizer by considerable proportion. A yield of 26,440 kilograms per hectar extracts 43 kilograms of nitrogen from the air. The tubercles are planted in February or March—or even during the winter, since they do not freeze—whenever the condition of the atmosphere and of the soil are suitable. From fifteen to twenty hecto-liters of tubercles, according to their size, are needed per hectar for planting, or from six to eight hectoliters if the rhizomes are small and the soil well manured. They are planted at a depth of six to ten centimeters with a space of 50 to 60 centimeters between the rows and about 30 centimeters apart. As soon as the young shoots appear the ground is raked, then in May they are given a second tilling and again in June. The development of the tubercles is favored also by hilling up. In general, the method of cultivation is the same as for the potato. The harvest is from the end of October to the end of March. The average yield is 350 to 400 hectoliters, *i. e.*, 25,000 to 28,000 kilograms per hectar. The harvest of the stalks to be used as dry fodder is gathered about the middle of September. It varies from eight to fourteen thousand kilograms per hectar.

This plant is of such vigorous growth that, unlike most kitchen vegetables, it chokes out weeds; correspondingly it is rather difficult to completely extirpate it when it is desired to change the crop. The varieties called *Datate* (potato) and *Fuscan* (spindle), have tubercles which are smoother and therefore easier to prepare for cooking. They are easily kept in a cellar or in a silo. They are easily preserved in good condition until the following July or August, the time at which they are usually fed to cattle.

[1]Quite recently Mr. L. Laurant, Botanical Curator at the Marseilles Museum called attention to a new and very practical utilization of the pith of the helianthus stalks. He suggests the use of this material in Histology for the purpose of enclosing or surrounding those plant organs of which it is desired to make microscopic sections for the purpose of studying their anatomy. The pith is easily pushed out of the stalks. It is not only very cheap, but because of its fineness of structure and its suitable diameter can be readily substituted in the laboratory for the pith of the elder which is less easy to prepare, often of too small a diameter and of comparatively high price when the diameter is of suitable dimensions, *i. e.*, over twelve millimeters.

Ptolemy's Geography of Albion

At a recent meeting of the Society of Antiquaries of Scotland, Professor Flinders Petrie communicated a paper on the above subject. The author first considered the astronomical basis for the principal points, and mentioned that there were no longitudes to employ, and that the latitudes were fixed, at least in Britain, solely by the hours in the longest day. He pointed out that in this calculation Ptolemy's reckoning was inaccurate, owing to the failure to observe with scientific accuracy the actual sun center above the horizon. This error was, in the author's opinion, the main source of the distortion of the map of Albion. The direct distance as plotted from London to Caturactorium (Catterick Bridge) is equal to that from the latter place to Alata Castra (Nairn), and he considered it very likely, therefore, that Polemy had a statement that Caturactorium was half way between the distant points. Owing to unfortunate errors in the length of the day, which placed Caturactorium 1 degree too far north of London and Alata Castra 1½ degrees too little north of Caturactorium, he had to fit one length into four degrees in England, and an equal length into only 1½ degrees in Scotland. The only possible way to reconcile these was to turn the northern length either to east or west, to fit it into 1½ degrees of latitude, thus the great distortion could, he believed, be definitely run down to the mistake of reckoning the day in Yorkshire to include twenty minutes more twilight than was reckoned in London or Nairn.

Action on Lead by Oak, Mortars and Concrete

It appears, from facts given in a short paper, presented to the Chemical Society some weeks ago, by Mr. J. S. S. Braine, and from the remarks made by several speakers in the discussion, that lead is acted on by green oak, and by mortars and concrete. In the first case corrosion occurs with the formation of a white deposit, and in the second case—at any rate, if the concrete is made with a coke breeze—with a red deposit. The reaction appears to be obscure. The action of oak is very slow, but of mortars relatively rapid.

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